

REMARKS

Claims 1-37 and 87-189 are pending in the patent application. Claims 91-160 and 172-189 have been cancelled without prejudice as a result of a restriction requirement. The Applicants reserve the right to pursue these claims in other patent applications. Claims 1, 22 and 161 have been amended to recite the phrase "wherein the carbon monoxide associated with the raw meat within the first package is adapted to be removable." Support for these amendments may be found at, for example, page 12, lines 2-12 and the examples of the present application. No new matter has been entered. After entry of these amendments, claims 1-37, 87-90 and 161-171 are present in the patent application.

I. Restriction Requirement/Election

The Applicants are confirming the election to proceed with claims 1-37, 87-90 and 161-171. The remaining claims of the application (claims 91-160 and 172-189) are being cancelled without prejudice as a result of this restriction requirement.

II. 35 U.S.C. § 103(a) Rejections

The Applicants are submitting herewith evidence in the form of a 37 C.F.R. §1.132 declaration by one skilled in the art of meat processing using modified atmosphere packaging (Dr. Melvin C. Hunt) (Exhibit 1) to assist in showing the non-obviousness of the invention.

The Applicants are also submitting herewith evidence in the form of a 37 C.F.R. §1.132 declaration by one of the co-inventors Mr. Gary R. DelDuca ("the DelDuca Second Declaration") (Exhibit 2) to assist in showing the commercial success of the invention. The Applicants note that Mr. DelDuca previously submitting a declaration ("the DelDuca First Declaration")<sup>1</sup> to assist in explaining the invention and showing the non-obviousness of the invention.

---

<sup>1</sup> The DelDuca First Declaration was filed with the Amendment and Response to Office Action Dated May 7, 2003.

**A. A *Prima Facie* Case Has Not Been Presented with Respect to Independent Claims 1, 22 and 161**

The present invention is directed to novel methods of manufacturing modified atmosphere packages. The present invention does not “fix” the color of the meat pigment to red with its use of carbon monoxide (CO), but rather the meat pigment tends to turn brown in a natural time period. *See* page 12, lines 10-12 of the application; Hunt Decl. ¶ 6; DelDuca Second Decl. ¶ 11. It is important to prevent the meat color from being “fixed” because it is unsafe (and potentially dangerous) to consume a piece of meat that has a bright red color that consumers associate with freshness, but is beyond the point of microbial soundness. *See* DelDuca Second Decl. ¶ 11.

Independent claims 1, 22 and 161 recite, *inter alia*, (a) “a first package including a non-barrier portion substantially permeable to oxygen”; (b) “a second package substantially impermeable to oxygen”; (c) a low oxygen environment that includes from about 0.1 to about 0.8 vol% carbon monoxide (CO) or from about 0.3 to about 0.5 vol% CO; and (d) “wherein the carbon monoxide associated with the raw meat within the first package is adapted to be removable.” The applied references in the Office Action do not teach or suggest such limitations that are recited in independent claims 1, 22 and 161.

As acknowledged in the Office Action at page 3, U.S. Patent No. 6,054,153 to Carr (“Carr”) is silent in teaching or suggesting the use of CO. The other applied reference (U.S. Patent No. 4,522,835 to Woodruff (“Woodruff”)) does not disclose a packaging system having (a) “a first package including a non-barrier portion substantially permeable to oxygen;” and (b) “a second package substantially impermeable to oxygen,” as recited in independent claims 1, 22 and 161. In response to the deficiencies of these applied references, the Office Action stated the following:

It would have been obvious to modify Carr et al. [Carr] and include anywhere from 0.1-0.8% carbon monoxide, 40 to 80% nitrogen, and 20-60% carbon dioxide in the modified atmosphere pocket (i.e., between the two packages) to convert the deoxymyoglobin to carboxymyoglobin...since Woodruff et al. [Woodruff] teach it is preferred to have a ‘good color’ (i.e. red color of fresh meat) for meat stored with a low/no oxygen modified atmosphere and this is done by adding 0.1 to 0.8% carbon monoxide along with 40-80% nitrogen and 20-60% carbon dioxide in the package. One would have been substituting one conventional carbon dioxide/nitrogen based atmosphere for another for the same purpose: providing a

low/no oxygen atmosphere for providing the appearance of fresh cut meat after storage.

Office Action at page 4.

This passage in the Office Action ignores the understanding of those of ordinary skill in the art that CO fixes the color of the meat and there would be no motivation to one of ordinary skill in the art for using CO in a modified atmosphere such as disclosed in Woodruff with a meat packaging system such as disclosed in Carr. The problems of fixing meat color with CO, which can mask spoilage, are clearly known to those of ordinary skill in the art. *See, e.g.*, Hunt Decl. ¶ 6; DelDuca Second Decl. ¶ 11. The problem of fixing meat color with CO was described in a previously applied reference in the Office Action dated May 7, 2003 to Sorheim et al.<sup>2</sup> Furthermore, the United States Food and Drug Administration (FDA) has believed that the meat pigment color would be fixed using CO.<sup>3</sup> Thus, the alleged “good” color (*i.e.*, red color of fresh meat) disclosed in Woodruff is not a desirable attribute when the meat pigment remains such a color past its microbial soundness. Thus, there is simply no motivation to combine Carr and Woodruff in an attempt to address the problems solved by the present invention and to read on the pending claims.

Additionally, Dr. Hunt, who has extensive experience in the processing of meat using modified atmosphere packaging, stated that “[t]he results of the testing [of the Pactiv’s improved ActiveTech® meat packaging system<sup>4</sup>] were surprising to me because it was understood by those skilled in the art that CO fixes (creates a stable form of myoglobin that could mask spoilage) the color of the meat pigment to red.” Hunt Decl. ¶ 6. Pactiv’s improved ActiveTech® meat

---

<sup>2</sup> The applied reference was “The storage life of beef and pork packaged in an atmosphere with low carbon monoxide and high carbon dioxide” from *Meat Science* to Sorheim et al. (“Sorheim”). In particular, Sorheim disclosed that its meat packaging systems with a modified atmosphere of “0.4% CO/60% CO<sub>2</sub>/40% N<sub>2</sub> had a bright stable red colour that lasted beyond the time of spoilage.” Abstract of Sorheim.

<sup>3</sup> Exhibit 3 (In a 1962 letter, the FDA told a Whirlpool representative that it might need additional data “to establish that the treatment of meat would not serve to cause the meat to retain its fresh red color longer than meat not so treated” and that the FDA has a question “concerning possible deception of the consumer where treatment of the meat leads to longer retention of the fresh red color.”); *see also* Hunt Decl. ¶ 6

packaging system did not fix the color of the meat pigment as expected and Dr. Hunt stated that “[t]his was a novel result and was not at all obvious due to the current and long standing thought that meat exposed to CO would develop a color that would mask spoilage.” *See id.*

One of the other applied references (U.S. Patent No. 5,711,978 to Breen (“Breen”)) has the same deficiencies as Carr. Specifically, Breen does not disclose the use of CO in its respective packaging system, let alone the claimed amount of CO recited in the independent claims. Breen discloses the use of a “substantially pure carbon dioxide” environment. *See, e.g.*, col. 5, lines 10-14. The other applied reference (the abstract DE 1935566 to Verbruggen (“Verbruggen”)) has the same deficiencies of Woodruff in that it simply discloses the use of CO and meat without discussing a packaging solution.

Thus, there is no motivation to combine the references of Carr, Woodruff, Breen, Verbruggen, or any combination thereof in an attempt to read on the pending claims. The mere fact that references can be combined together or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680 (Fed. Cir. 1990). “When a rejection depends on a combination of prior art references, there must be some teaching, suggestion, or motivation to combine the references.” *Rouffet*, 149 F.3d at 1355, 47 U.S.P.Q.2d at 1456, (*citing In re Geiger*, 815 F.2d 686, 688, 2 U.S.P.Q.2d 1276, 1278 (Fed. Cir. 1987)). Evidence of a suggestion, teaching, or motivation to combine “must be clear and particular.” *See Ex parte Maruyama*, 2001 WL 1918556, \*3 (Bd. Pat. App. & Inter. 2001), (*citing C.R. Bard, Inc. v. M3 Sys. Inc.*, 157 F.3d 1340, 1352, 48 U.S.P.Q.2d 1225, 1232 (Fed. Cir. 1998)).

Obviousness cannot “be established using hindsight or in view of the teachings or suggestions of the invention.” *Ex parte Maguire* (Appendix 9), 2002 WL 1801466, \*4 (Bd. Pat. App. & Inter. 2002), (*quoting Para-Ordnance Mfg. Inc. v. SGS Imps. Int’l Inc.*, 73 F.3d 1085, 1087, 37 U.S.P.Q.2d 1237, 1239 (Fed. Cir. 1995), *cert. denied*, 519 U.S. 822 (1996)). In other words, the knowledge to combine “can not come from the applicant’s invention itself.” *In re Oetiker*, 977 F.2d 1443, 1447, 24 U.S.P.Q.2d 1443, 1446 (Fed. Cir. 1992) (emphasis added).

---

<sup>4</sup> The process of Pactiv’s ActiveTech® improved meat packaging system is one process that would be covered by the pending independent claims.

Thus, the Applicants believe that a *prima facie* case has not been presented with Carr, Woodruff, Breen, Verbruggen, or any combination thereof.

**B. Evidence of Non-Obviousness of Independent Claims 1, 22 and 161**

Assuming, *arguendo*, that a *prima facie* case has been presented (which Applicants believe is not the case), the Applicants are submitting evidence of non-obviousness in the form of two declarations – the Hunt Declaration (Exhibit 1) and the DelDuca Second Declaration (Exhibit 2) to assist in showing the non-obviousness of the invention.

**i. CO Not Allowed with Fresh Meat in the United States Since At Least 1962**

CO had not been allowed to be used with fresh meat in the United States for about 40 years. *See* Exhibit 3 (1962 Whirlpool letter); DelDuca Second Decl. ¶ 11. The concern of the FDA is believed to be that CO fixes the fresh meat color to a degree that allows the retailer to sell meat that looks good (a bright red color), but is beyond the point of microbial soundness. *Id.*

**ii. CO Now Allowed In Pactiv's Improved ActiveTech ® Meat Packaging System**

After about 40 years of not allowing CO to be used with fresh meats in the United States, the Applicants came up with novel approaches of using CO in modified atmosphere packaging (MAP) systems that avoided the concerns of “fixing” the meat color. DelDuca Second Decl. ¶ 11.

The specific MAP system that was presented in the GRAS notice was Pactiv's improved ActiveTech® meat packaging system. The improved ActiveTech® meat packaging system included meats being placed in polystyrene trays and covered with oxygen-permeable, polyvinyl chloride (“PVC”) overwraps. DelDuca Second Decl. ¶ 5. The wrapped trays of meat are then placed in an outer barrier bag. Ambient air is removed and replaced with a blend of 0.4% CO, 30% carbon dioxide, and the balance being nitrogen. *Id.*

The FDA stated that it had no questions regarding Pactiv's conclusion about Pactiv's improved ActiveTech® meat packaging system using 0.4% CO being GRAS because of the

evidence presented by Pactiv in its notice. DelDuca Second Decl. ¶ 12. This FDA review allows Pactiv to use CO with fresh meat in its application. *Id.* It is believed to be the first system to overcome the prohibition of CO with fresh meat in the United States in the last 40 years. *Id.*

Thus, a problem of fixing meat color with CO that was recognized for at least the last 40 years was overcome by Pactiv's improved ActiveTech® meat packaging system and process of the same. The process of manufacturing using Pactiv's improved ActiveTech® meat packaging system is an example of a process that would be covered under independent claims 1, 22 and 161 of the present application. *Id.* at 10.

**iii. The Pactiv Improved ActiveTech® Meat Packaging System and Process Addresses a Long-Felt Need**

The Federal Circuit has stated that if an invention unexpectedly solved longstanding problems, it supports the conclusion of nonobviousness. *See, e.g., Hybritech Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1382 (Fed. Cir 1986); *WMS Gaming Inc. v. Intl.Game Tech.*, 184 F.3d 1339, 1359 (Fed. Cir. 1999).

The process of manufacturing Pactiv's improved ActiveTech® meat packaging system, which is an example of a process that would be covered under independent claims 1, 22 and 161 of the present application, addressed such a long-felt need in the meat-packaging industry. "Prior to Pactiv's [improved] ActiveTech® meat packaging system using 0.4 vol.% CO, there was a need in the industry to provide a solution that: (a) reduced the seasoning period (the critical time meat is exposed to low partial pressures of oxygen, which can seriously damage the pigment chemistry); (b) formed consistently a normal bloomed color with meats whose pigment is sensitive to metmyoglobin formation; and (c) avoided the fixing of too stable of a meat color, which can be unsafe and potentially dangerous, if the color stability was greater than the shelf life (microbial soundness) of the product." Hunt Decl. ¶ 7. "Such a solution was especially desirable for a centralized packaging facility where the meat would be shipped to distant locations." *Id.* "Pactiv's [improved] ActiveTech® meat packaging system using 0.4 vol.% CO was a new and novel approach that addressed these technological needs." *Id.* Dr. Hunt stated that the results of the testing of Pactiv's ActiveTech® meat packaging system were surprising. *See id.* at ¶¶ 5,6.

Thus, since Pactiv's improved ActiveTech® meat packaging process surprisingly addressed a long-felt need, this is further evidence that the independent claims of the present application are not obvious over the applied references.

**iv. The Pactiv Improved ActiveTech® Meat Packaging System and the Process of Using the Same is Commercially Successful**

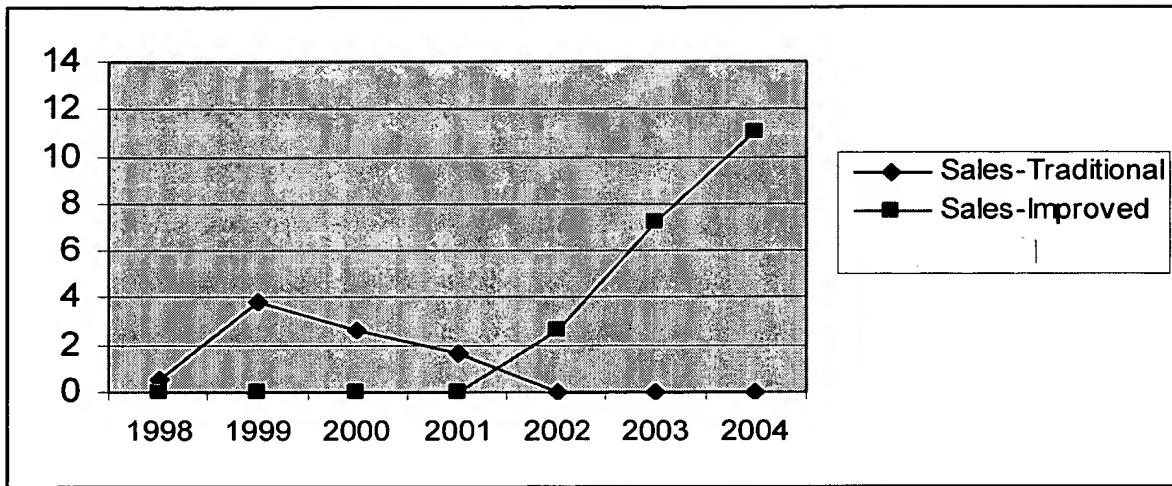
The Federal Circuit has also stated that “[c]ommercial success is ... a strong factor favoring non obviousness.” *See, e.g., Akzo N.V. v. U.S. Int'l Trade Comm'n*, 808 F.2d 1471, 1481 (Fed. Cir. 1986); *Gambro Lundia AB v. Baxter Healthcare Corp.*, 110 F.3d 1573, 1580 (Fed. Cir. 1997).

The process of manufacturing using Pactiv's improved ActiveTech® meat packaging system, which is one process that would be covered under independent claims 1, 22 and 161, has been commercially successful. DeDuca Second Decl. ¶¶ 8,10. This is shown by the commercial sales of Pactiv's improved ActiveTech® meat packaging system. *Id.*

Pactiv sold modified atmosphere packaging systems (without using CO) beginning in 1998 (the traditional ActiveTech® meat packaging system). DeDuca Second Decl. ¶ 4. Beginning in March of 2002, Pactiv began offering for sale an improved ActiveTech® meat packaging system. *Id.* at ¶ 5. Pactiv's improved ActiveTech® meat packaging system uses 0.4 vol.% CO, while Pactiv's traditional ActiveTech® meat packaging system does not use CO. *Id.*

As shown below in the Graph, sales of Pactiv's traditional ActiveTech® meat packaging system were decreasing in 2000 and 2001. *Id.* at ¶ 8. The sales of Pactiv's improved ActiveTech® meat packaging system, however, have substantially increased since its introduction in March of 2002. *Id.* The sales of Pactiv's improved ActiveTech® meat packaging system have been commercially successful as shown by the sales of over 7 million dollars in 2003 and an estimated sales of 11 million for 2004. *Id.*

GRAPH



Since March of 2002, both Pactiv's improved ActiveTech® meat packaging system and Pactiv's traditional ActiveTech® meat packaging system have been available for sale. *Id.* at ¶ 9. Since March 2002, no customer has purchased Pactiv's traditional ActiveTech® meat packaging system. *Id.* It can be concluded that these customers prefer Pactiv's improved ActiveTech® meat packaging system over Pactiv's traditional ActiveTech® meat packaging system. The cost of Pactiv's improved ActiveTech® meat packaging system versus Pactiv's traditional ActiveTech® meat packaging system is fractionally more expensive. *Id.* Thus, the commercial success of Pactiv's improved ActiveTech® meat packaging system cannot be attributed to a cost advantage. *Id.*

Thus, since the process of manufacturing Pactiv's improved ActiveTech® meat packaging process has been commercially successful, this is further evidence that the independent claims of the present application are not obvious over the applied references.

Therefore, in addition to the applied references not presenting a *prima facie* case, the Applicants also believe that the present invention is allowable because of the compelling evidence of non-obviousness. Therefore, independent claims 1, 22 and 161 are not obvious in view of Carr, Woodruff, Breen, Verbruggen or any combination thereof and, thus, should be in a condition for allowance.

**C. Dependent Claims 2-21, 23-37, 87-90 and 162-171**

Dependent claims 2-21, 23-37, 87-90 and 162-171, which depend directly or indirectly on independent claim 1, 22 or 161, are not obvious in view of Carr, Woodruff, Breen, Verbruggen or any combination thereof for at least the same reasons discussed with respect to claims 1, 22 and 161. Thus, claims 2-21, 23-37, 87-90 and 162-171 should be in a condition for allowance.

**D. Conclusion**

The Applicants submit that the claims are in a condition for allowance and action toward that end is earnestly solicited. The Applicants have enclosed a check in the amount of \$110.00 for a one month extension of time. It is believed that no further fees are due; however, should any additional fees be required (except for payment of the issue fee), the Commissioner is authorized to deduct the fees from Jenkens & Gilchrist, P.C. Deposit Account No. 10-0447, Order No. 47097-01080.

Respectfully submitted,



---

John C. Gatz  
Reg. No. 41,774  
JENKENS & GILCHRIST, P.C.  
225 West Washington Street  
Suite 2600  
Chicago, IL 60606-3418  
(312) 425-3900 - telephone

Attorneys for Applicants

June 16, 2004  
Date



PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No. : 09/915,150  
Applicant : Gary R. DelDuca *et al.*  
Filed : July 25, 2001  
Title : Modified Atmospheric Packages and Methods for Making the Same  
  
TC/A.U. : 1761  
Examiner : Robert A. Madsen  
  
Docket No. : 47097-01080

**DECLARATION OF DR. MELVIN C. HUNT  
UNDER 37 C.F.R. § 1.132**

Mail Stop Amendment-Fee  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313

**CERTIFICATE OF MAILING**  
37 C.F.R. 1.8

I hereby certify that this correspondence is being deposited with the U.S. Postal Service as First Class Mail in an envelope addressed to: Mail Stop Amendment-Fee, Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313 on the date indicated below:

June 16, 2004  
Date

Adrienne White

Dear Commissioner:

I, Dr. Melvin C. Hunt, declare that:

1. I hold a degree of B.S. in Animal Husbandry from Kansas State University in Manhattan, Kansas that was obtained in 1965. I hold a degree of M.S. in Animal Science from Kansas State University that was obtained in 1970. I hold a degree of Ph.D. in Food Science from the University of Missouri in Columbia, Missouri that was obtained in 1973.

2. From 1973-1975, I worked as a research chemist for Tennessee Eastman Company in Kingsport, Tennessee in the health and nutrition division. Since 1975 to the present, I have held various professor positions at Kansas State University. Since 1991, I have been the Chair of

the Undergraduate Food Science Program at Kansas State University. I have taught several courses over the years at Kansas State University and some of those courses include the following: Meat Science, Processed Meat Operations, Advance Meat Science, Food Science Seminar, Topics in Meat Science and Muscle Biology, Meat Processing, and Livestock and Meat Evaluation. I have also performed numerous research projects in Meat Science and Muscle Biology including major emphasis on pigment chemistry, meat color, meat packaging, and factors effecting microbial soundness (shelf life) of meat. Thus, I have extensive experience in the processing of meat using modified atmosphere packaging.

3. My curriculum vita (attached as Exhibit A) details my professional affiliations related to animal science and meat science. I have served as President of the American Meat Science Association in 1995-1996, Chair of the Meat Science-Muscle Biology Section of National American Society of Animal Science ("ASAS"), Chair of the Midwestern ASAS Meat Science Section, and Chair of the Muscle Foods Division of the Institute of Food Technologists. I have been on the Editorial Board of the publication entitled "Journal of Muscle Foods." I also perform manuscript review for several peer-reviewed scientific publications including "Meat Science", "Journal of Muscle Foods", "Journal of Animal Science", and "Journal of Food Science

4. I assisted in preparing some of the information included in Pactiv's GRAS notice (Exhibit B) that was filed with the Food and Drug Administration (FDA) on August 29, 2001. The specific modified atmosphere packaging (MAP) system that was presented in the GRAS notice as a meat packaging system containing 0.4 vol.% CO and was referred to in the notice as Pactiv's ActiveTech® meat packaging system. The ActiveTech® meat packaging system placed meat in polystyrene trays, which were covered with oxygen-permeable, polyvinyl chloride (PVC)

overwraps. The wrapped trays of meat were then placed in an outer barrier bag. Air was removed and replaced with a blend of 0.4 vol.% CO, 30 vol.% carbon dioxide, and the balance being nitrogen.

5. I performed a series of tests on the effects of the ActiveTech® meat packaging system with CO on fresh meat color, color stability, and shelf life. The conclusions reached for the ActiveTech® meat packaging system with CO were: (a) the color of Pactiv's ActiveTech® meat packaging system using CO resulted in products that were equally red to products packaged with traditional oxygen permeable overwrap; (b) color deterioration of meat during simulated retail display in Pactiv's ActiveTech® meat packaging system using CO compared well to products packaged with traditional oxygen permeable overwrap; (c) bacterial growth was neither encouraged nor suppressed by adding CO to Pactiv's ActiveTech® meat packaging system; and (d) CO in the ActiveTech® meat packaging system neither masked spoilage, nor extended color life beyond the point of microbial soundness. I further concluded that Pactiv's ActiveTech® meat packaging system using 0.4 vol.% CO might be eligible for GRAS status.

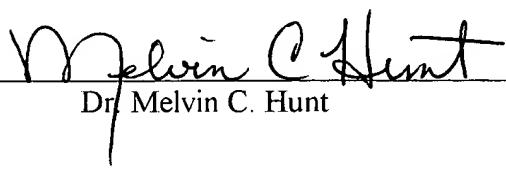
6. The results of the testing were surprising to me because it was understood by those skilled in the art that CO fixes (creates a stable form of myoglobin that could mask spoilage) the color of the meat pigment to red. This is believed to be the reason on why CO had not been allowed to be used with fresh meat in the United States for many years. Pactiv's ActiveTech® meat packaging system using 0.4 vol.% CO, however, did not fix the color of the meat pigment to red. Rather, the meat pigment turned brown (discolored) in a pattern typical of retail meat in display but packaged in a standard supermarket format (foam tray and PVC overwrap). This was a novel result and was not at all obvious due to the current and long standing thought that meat

exposed to CO would develop a color that would mask spoilage. In other words, the pigment of the meat when exposed to CO would produce an extremely stable form of the pigment, but this did not happen in the Pactiv Active Tech® system.

7. Prior to Pactiv's ActiveTech® meat packaging system using 0.4 vol.% CO, there was a need in the industry to provide a solution that: (a) reduced the seasoning period (the critical time meat is exposed to low partial pressures of oxygen, which can seriously damage the pigment chemistry); (b) formed consistently a normal bloomed color with meats whose pigment is sensitive to metmyoglobin formation; and (c) avoided the fixing of too stable of a meat color, which can be unsafe and potentially dangerous, if the color stability was greater than the shelf life (microbial soundness) of the product. Such a solution was especially desirable for a centralized packaging facility where the meat would be shipped to distant locations. Pactiv's ActiveTech® meat packaging system using 0.4 vol.% CO was a new and novel approach that addressed these technological needs.

8. I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true; and, further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: 6-14-04

  
Dr. Melvin C. Hunt

# MELVIN C. HUNT

Department of Animal Sciences and Industry  
Weber Hall  
Kansas State University  
Manhattan, KS 66506-0201

Ph: 913-532-1232  
Fax: 913-532-7059  
[Hhunt@oznet.ksu.edu](mailto:Hhunt@oznet.ksu.edu)

## PERSONAL DATA:

Born: February 10, 1942

Married: Rae Jean Opie, August 20, 1965; Daughters: Paige and Holly

## EDUCATION:

B.S. 1965 Animal Husbandry, Kansas State University, Manhattan, KS

M.S. 1970 Animal Science, Kansas State University, Manhattan, KS

Ph.D. 1973 Food Science, University of Missouri, Columbia, MO

## PROFESSIONAL EXPERIENCE:

1991- Chair, Undergraduate Food Science Program

1984- Professor, Kansas State University: 50% Teaching - 50% Research

1978-84 Associate Professor, Kansas State University

1975-78 Assistant Professor, Kansas State University

1973-75 Research Chemist, Tennessee Eastman Company

1968-73 Grad Research Assistant, Kansas State and University of Missouri

1966-68 Taught high school chemistry and biology, Kinsley, KS

## PROFESSIONAL AFFILIATIONS:

### American Meat Science Association:

- President, 1995-96; Past-President, 1996-97

- Director and Executive Board, 1989-91

- Chair 1991 Reciprocal Meat Conference

- Parliamentarian

- Chair or member of numerous committees including:

Meat Color Guidelines, AMSA Teaching Award, Undergraduate Travel Award, Grad Student Poster Competition, Teaching Display, Resolutions, Meat Tenderness, Biochemistry-Biophysics, Packaging, Meat Color, Growth and Development, Reciprocation, Long Range Planning, Sustaining Membership, Endowment, and Research Priorities.

### American Society of Animal Science:

- Chair and Chair-elect, Meat Science-Muscle Biology Section of National ASAS Meeting

- Chair, Midwestern ASAS Meat Science Section

- Editorial Board Journal Animal Science

- Teaching Award Committee, Midwestern ASAS Section

### Institute of Food Technologists:

- Chair and Chair-elect of Muscle Foods Division, 1992-94

- Director of Muscle Foods Division

- Chair of Muscle Foods Nominating Committee

- Committee for two National Muscle Foods Symposia

- Journal of Food Science, Manuscript Review

- CAST: Contributing member

Journal of Muscle Foods: Editorial Board

Meat Science: Manuscript Review

**HONORARY AFFILIATIONS:**

Phi Kappa Phi, Sigma Xi, Phi Tau Sigma, Gamma Sigma Delta, Alpha Zeta

**HONORS:**

- College of Agriculture Outstanding Faculty Award 1979
- College of Agriculture Outstanding Faculty Award 1982
- College of Agriculture Outstanding Faculty Award 1988
- College of Agriculture Outstanding Faculty Award 1998
- College of Agriculture Outstanding Academic Advisor 1983
- University Selection for Parents' Day Lecture 1979
- Outstanding Lecturer Award, ITAL, Campinas, Brazil 1981
- Honorary State Farmer Degree 1985
- Distinguished Teaching Award, Gamma Sigma Delta 1989
- Selected Instructor, National Food Science Satellite Program 1990
- Certificate of Meritorious Service, Kansas Ag Teachers Association 1992
- CASE Professor of the year, Kansas winner of national competition 1992
- Outstanding Advising Award, Gamma Sigma Delta 1994
- Distinguished Teaching Award, American Meat Science Association 1994
- Outstanding Food Scientist, Phi Tau Sigma 1996
- Outstanding KSU Instructor & Advisor Award, Mortar Board 1997
- Signal Service Award, American Meat Science Association 1997
- USDA Food & Agriculture Science Excellence in Teaching Award, 2000

**DEPARTMENT, COLLEGE OF AG, AND UNIVERSITY ACTIVITIES:**

- Faculty Advisor: Block and Bridle, 6 years
- Faculty Advisor: Food Science Club, 3 years
- Faculty Advisor: Animal Science Grad Student Association, 16 years
- Faculty Advisor: Ag Student Council, elected for 2 terms (4 years)
- Chair, Weber Hall Building/Renovation Project
- Chair, KSU Meat Science Faculty
- Coordinator of KSU Meat Research Labs
- ASI Graduate Student Selection Committee
- ASI Undergraduate Career Development Committee
- ASI Library Committee
- ASI Scholarship, Loans and Honors Committee
- Department Representative for Gamma Sigma Delta, 10 years
- Student Team Coordinator, ASI Quadrathalon Teams
- Agriculture Student of the Month Selection Committee
- Agriculture Faculty of the Semester Selection Committee
- College of Agriculture Course and Curriculum Committee, chair and member
- College of Agriculture Academic Standards Committee, chair and member
- College of Agriculture Commencement Committee
- University Faculty Senator, College of Agriculture, two terms (6 years)
- University Academic Affairs Committee
- University Coordinating Committee for United Way
- KAES NCR-121 Chair and Secretary: Food & Feed Safety in Animal Production
- Food Science Undergraduate and Graduate Steering Committees
- Chair, Non-Traditional Studies Advisory Committee
- Elected by peers to ASI Teaching Advisory Committee
- Chair, KSU Undergraduate Food Science Program: Coordinate all course & curriculum and policy matters, scholarship, internships, recruitment, and record keeping

**INDUSTRY-EXTENSION ACTIVITIES:**

- Numerous presentations at: MidWest Meat Processors Seminars, Kansas-Nebraska Curing and Sausage Short Courses, KSU Cattlemen's Day, KSU Swine Day
- Technical Assistance for: Tennessee Eastman Company, Ross Industries, Giant Food

Stores, Excel Corporation, IBP, Doskocil Companies, Tenneco Packaging, Farmland, National Beef, Cryovac, Buckhead Beef, Dupont, Kalsec, Wendy's, Greater Omaha Beef, Hormel

- State FFA Livestock Awards Selection Committee
- State FFA Star Farmer Selection Committee
- State FFA Public Speaking Contest Judge
- Kansas Jr. Livestock Carcass Contest Judge
- Kansas Meat Processor Cured Meat Show Judge
- Missouri Meat Processor Cured Meat Show Judge

#### **TEACHING RESPONSIBILITIES:**

##### **Current Courses - KSU Campus:**

- ASI 350 Meat Science. 3hr. Lecture-lab introductory meat science  
Enrollment: Since 1979, 2031 students; currently running at maximum seating of 72
- ASI 610 Processed Meat Operations. 2hr. 50% responsibility, value-added processing  
Enrollment: 6 to 12 undergraduate and graduate students; since 1988, 35 students
- ASI 930 Advanced Meat Science. 3hr. Team-taught, highest level meats course  
Enrollment: Varies from 6 to 15 graduate students
- GENAG 500 Food Science Seminar. 1hr. Seminar for graduating seniors  
Enrollment: Varies from 6 to 15 students

##### **Current Courses - KSU Distance Learning Program:**

- ASI 340 Principles of Meat Science. 2hr. Web-based course for Continuing Education  
Enrollment: Since 1987, over 680 students
- GENAG 500 Food Science Seminar. 1hr. Seminar series for Distance Learning majors  
Enrollment: 3 to 15 undergraduate students per year, Continuing Education
- GENAG 630 Food Science Problems. 1hr. Detailed written investigation of current topics  
Enrollment: 2 to 8 students per year through Continuing Education

##### **Previously Taught Courses:**

- Topics in Meat Science and Muscle Biology
- Meats Judging Team (at University of Missouri)
- Meat Processing
- Livestock and Meat Evaluation
- Animal Agriculture and Consumers

#### **INTERNATIONAL COURSE ACTIVITIES:**

- Meat Science and Technology Short Course for Latin America, Institute for Food Technology, Campinas, Brazil, 6 weeks, one of two international lecturers
- Meat Science Facilities, University of Monterrey, Monterrey, Mexico
- Lecturer for five KSU International Meat Science Courses, International Meat and Livestock Program, Kansas State University
- Sabbatical leave, fall 1992, visiting scientist to Norwegian Food Research Institute, As
- Have attended 8 International Congresses of Meat Science and Technology

#### **ADVISING RESPONSIBILITIES:**

#### RESEARCH INTERESTS:

- Myoglobin chemistry and meat color, Methods of color measurement, Cooked meat color and food safety, Postmortem factors affecting meat quality, Collagen chemistry, Low-fat ground beef and processed meats; Six major company packaging projects funded since 1994 dealing with shelf life, color life, cold chain management, product palatability, and microbiology

## PUBLIC AND COMMUNITY ACTIVITIES:

- Manhattan Optimist Club: committees for many youth activities
- Coach, Girls (16-18) ASA fast pitch softball traveling team
- Executive Committee, Riley County Extension Council
- Asst. Superintendent, sheep division, Riley County Fair
- Judge at Manhattan High School oratorical contest
- FarmHouse Fraternity, alumni board and committee work
- Snyder Award for Alumni Service, FarmHouse Fraternity
- Activities of First Presbyterian Church

Melvin C. Hunt  
Professor  
Department of Animal Sciences and Industry  
Kansas State University

Refereed Journal Articles

Hunt, M.C., R.A. Smith, D.H. Kropf and H.J. Tuma. 1975. Factors affecting showcase color stability of frozen lamb in transparent film. *J. Food Sci.* 40:637.

Hunt, M.C. and H.B. Hedrick. 1977. Profile of fiber types and related properties of five bovine Muscles. *J. Food Sci.* 42:513.

Hunt, M.C. and H.B. Hedrick. 1977. Histochemical and histological characteristics of bovine muscle from four quality groups. *J. Food Sci.* 42:578.

Hunt, M.C. and H.B. Hedrick. 1977. Chemical, physical and sensory characteristics of bovine muscle from four quality groups. *J. Food Sci.* 42:716.

Thomas, J.D., D.M. Allen, M.C. Hunt and C.L. Kastner. 1977. Nutritional regimen, post-slaughter conditioning temperature, and vacuum packaging effects on beef carcass and retail cut bacteriology. *J. Food Prot.* 40:678.

Harrison, A.R., M.E. Smith, D.M. Allen, M.C. Hunt, C.L. Kastner and D.H. Kropf. 1978. Nutritional regimen effects on quality and yield characteristics of beef. *J. Anim. Sci.* 47:383.

Loveday, H.D., M.E. Dikeman, M.C. Hunt and A.D. Dayton. 1978. Adipose tissue water related to bovine carcass composition. *J. Anim. Sci.* 47:606.

Smith, M.E., C.L. Kastner, M.C. Hunt, D.H. Kropf and D.M. Allen. 1979. Elevated conditioning temperature effects on carcasses from four nutritional regimens. *J. Food Sci.* 44:158.

Gutowski, G.H., M.C. Hunt, C.L. Kastner, D.H. Kropf and D.M. Allen. 1979. Vacuum aging, display, and level of nutrition effects on beef quality. *J. Food Sci.* 44:140.

Fung, D.Y.C., C.L. Kastner, M.C. Hunt, M.E. Dikeman and D.H. Kropf. 1980. Mesophilic and psychrotrophic populations on hot-boned and conventionally processed beef. *J. Food Prot.* 43:547.

Hayward, L.H., M.C. Hunt, C.L. Kastner and D.H. Kropf. 1980. Blade tenderization effects on beef longissimus sensory and Instron textural measurements. *J. Food Sci.* 45:925.

Harrison, A.R., D.H. Kropf, D.M. Allen, M.C. Hunt and C.L. Kastner. 1980. Relationships of spectrophotometric reflectance measurements to beef muscle visual color. *J. Food Sci.* 45:1052.

Burson, D.E., M.C. Hunt, D.M. Allen, C.L. Kastner and D.H. Kropf. 1980. Ration energy density and time on feed effects on beef longissimus palatability. *J. Anim. Sci.* 51:875.

Fung, D.Y.C., C.L. Kastner, C-Y. Lee, M.C. Hunt, M.E. Dikeman and D.H. Kropf. 1981. Initial chilling rate effects on bacterial growth of hot-boned beef. *J. Food Prot.* 44:539.

Wu, J.J., D.M. Allen, M.C. Hunt, C.L. Kastner and D.H. Kropf. 1981. Nutritional effects on beef collagen characteristics and palatability. *J. Anim. Sci.* 53:1256.

Hall, J.B. and M.C. Hunt. 1982. Collagen solubility of A-maturity bovine longissimus muscle as affected by nutritional regimen. *J. Anim. Sci.* 55:321.

Sleper, P.S., M.C. Hunt, D.H. Kropf, C.L. Kastner and M.E. Dikeman. 1983. Electrical stimulation effects on myoglobin properties of bovine longissimus muscle. *J. Food Sci.* 48:479.

Axe, J.E. Bowles, C.L. Kastner, M.E. Dikeman, M.C. Hunt, D.H. Kropf and G.A. Milliken. 1983. Effects of beef carcass electrical stimulation, hot boning, and aging on unfrozen and frozen longissimus dorsi and semimembranosus steaks. *J. Food Sci.* 48:332.

Lyon, M., C.L. Kastner, M.E. Dikeman, M.C. Hunt, D.H. Kropf and J.R. Schwenke. 1983. Effects of electrical stimulation, aging, and blade tenderization hot-boned beef psoas major and triceps brachii muscles. *J. Food Sci.* 48:131.

Greathouse, J.R., M.C. Hunt, M.E. Dikeman, L.R. Corah, C.L. Kastner and D.H. Kropf. 1983. Ralgro implanted bulls: performance, carcass characteristics, longissimus palatability and carcass electrical stimulation. *J. Anim. Sci.* 57:355.

Burson, D.B., M.C. Hunt, D.E. Schafer, D. Beckwith and J.R. Garrison. 1983. Effects of stunning method and time interval from stunning to exsanguination on blood splashing in pork. *J. Anim. Sci.* 57:918.

Shivas, S.D., D.H. Kropf, M.C. Hunt, C.L. Kastner, J.L.A. Kendall and A.D. Dayton. 1984. Effects of ascorbic acid on the display life of ground beef. *J. Food Prot.* 47:11.

Choi, Y.I., C.L. Kastner, M.E. Dikeman, M.C. Hunt and D.H. Kropf. 1984. Effects of electrical stimulation and hot boning on functional characteristics of preblended beef muscle in model systems. *J. Food Sci.* 49:867.

Claus, J.R., D.H. Kropf, M.C. Hunt, C.L. Kastner and M.E. Dikeman. 1984. Effects of beef carcass electrical stimulation and hot boning on muscle display color of polyvinylchloride packaged steaks. *J. Food Sci.* 49:1021.

Kropf, D.H., M.E. Dikeman, M.C. Hunt and H.R. Cross. 1984. Lighting type and intensity effects on beef carcass grade factors. *J. Anim. Sci.* 59:105.

Shivas, S.D., C.L. Kastner, M.E. Dikeman, M.C. Hunt and D.H. Kropf. 1985. Effects of electrical stimulation, hot boning, and chilling on bull semimembranosus muscle. *J. Food Sci.* 50:36.

Claus, J.R., D.H. Kropf, M.C. Hunt, C.L. Kastner and M.E. Dikeman. 1985. Effects of beef carcass electrical stimulation and hot boning on muscle display color of unfrozen vacuum packaged steaks. *J. Food Sci.* 50:881.

Dikeman, M.E., A.D. Dayton, M.C. Hunt, C.L. Kastner, J.B. Axe and H.J. Ilg. 1985. Conventional versus accelerated beef production with carcass electrical stimulation. *J. Anim. Sci.* 61:573.

Burson, D.E. and M.C. Hunt. 1986. Proportion of collagen types I and III in four bovine muscles differing in tenderness. *J. Food Sci.* 51:51.

Burson, D.E. and M.C. Hunt. 1986. Heat-induced changes in the proportion of types I and III collagen in bovine longissimus. *Meat Sci.* 17:153.

Burson, D.E., M.C. Hunt, J.A. Unruh and M.E. Dikeman. 1986. Proportion of types I and III collagen in longissimus collagen from bulls and steers. *J. Anim. Sci.* 63:453.

Flores, H.A., C.L. Kastner, D.H. Kropf and M.C. Hunt. 1986. Effects of blade tenderization and trimming of connective tissue on hot-boned, restructured, pre-cooked roast from cows. *J. Food Sci.* 51:1176.

Unruh, J.A., C.L. Kastner, D.H. Kropf, M.E. Dikeman and M.C. Hunt. 1986. Effects of low-voltage electrical stimulation during exsanguination on meat quality and display colour stability. *Meat Sci.* 18:281.

Allen, D.M., M.C. Hunt, A. Luchiari Filho, R.J. Danler and S.J. Goll. 1987. Effects of spray-chilling and carcass spacing on beef carcass cooler shrink and grade factors. *J. Anim. Sci.* 64:165.

McCormick, R.J., D.H. Kropf, G.R. Reeck, M.C. Hunt and C.L. Kastner. 1987. Effect of heating temperature and muscle type on porcine muscle extracts as determined by reverse phase high performance liquid chromatography. *J. Food Sci.* 52:1481.

Kluber, E.F. III, J.E. Minton, J.S. Stevenson, M.C. Hunt, D.L. Davis, T.A. Hoagland and J.L. Nelissen. 1988. Growth, carcass traits, boar odor and testicular and endocrine functions of male pigs fed a progestogen, Altrenogest. *J. Anim. Sci.* 66:470.

Johnson, R.D., M.C. Hunt, D.M. Allen, C.L. Kastner, R.J. Danler and C.C. Schrock. 1988. Moisture uptake during washing and spray chilling of holstein and beef-type steer carcasses. *J. Animal. Sci.* 66:2180.

Claus, J.R., M.C. Hunt and C.L. Kastner. 1989. Effects of substituting added water for fat on the textural, sensory, and processing characteristics of bologna. *J. Muscle Foods.* 1:1.

Claus, J.R., M.C. Hunt, C.L. Kastner and D.H. Kropf. 1990. Low-fat, high-added water bologna: Effects of massaging, preblending, and time of addition of water and fat on the physical and sensory characteristics. *J. Food Sci.* 55:338.

Kenney, P.B. and M.C. Hunt. 1990. Effect of water and salt content on protein solubility and water retention of meat preblends. *Meat Sci.* 27:173.

Troyer, D.L., R.O. Oyster and M.C. Hunt. 1991. A combination histochemical stain for equine muscle. *Anat. Histol. Embryol.* 20:44.

Whipple, G., M. Koohmaraie, M.E. Dikeman, J.D. Crouse, M.C. Hunt and R.D. Klemm. 1990. Evaluation of attributes that affect longissimus muscle tenderness in *Bos Taurus* and *Bos Indicus* cattle. *J. Anim. Sci.* 68:2716.

Claus, J.R. and M.C. Hunt. 1991. Characteristics of low-fat, high-added water bologna formulated with textural modifying ingredients. *J. Food Sci.* 56:643.

Whipple, G., M.C. Hunt, R.D. Klemm, D.H. Kropf, R.D. Goodband, J.L. Nelissen, R.H. Hines and B.R. Schricker. 1992. Effects of porcine somatotropin and supplemental lysine on porcine muscle histochemistry. *J. Muscle Foods.* 3:217.

Troutt, E.S., M.C. Hunt, D.E. Johnson, J.R. Claus, C.L. Kastner, D.H. Kropf and S. Stroda. 1992. Chemical, physical, and sensory characterization of ground beef containing 5 to 30 percent fat. *J. Food Sci.* 57:25.

Troutt, E.S., M.C. Hunt, D.E. Johnson, C.L. Kastner and D.H. Kropf. 1992. Characteristics of low-fat ground beef containing texture-modifying ingredients. *J. Food Sci.* 57:19.

Goff, S.J., C.L. Kastner, M.C. Hunt and D.H. Kropf. 1992. Effects of glucose and internal cooking temperature on the characteristics of low fat, pre- and post-rigor restructured beef roasts. *J. Food. Sci.* 57:834.

Nold, R.A., J.A. Unruh, M.C. Hunt and C.W. Spaeth. 1992. Effects of implanting ram and wether lambs with zeranol at birth and weaning on palatability and muscle collagen characteristics. *J. Anim. Sci.* 70:2752.

Warren, K.E., M.C. Hunt, C.L. Marksberry, O. Sørheim, D.H. Kropf and M.J. Windisch. 1992. Modified-atmosphere packaging with carbon dioxide for bone-in pork loins. *J. Muscle Foods.* 3:283.

Nold, R.A., J.A. Unruh, C.W. Spaeth and M.C. Hunt. 1992. Effects of implanting ram and wether lambs with zeranol on pelt characteristics and removal. *Sheep Res. J.* 8:81.

Brester, G.W., P. Lhermite, B.K. Goodwin and M.C. Hunt. 1993. Quantifying the effects of new product development: The case of low-fat ground beef. *J. Agric. & Resource Econ.* 18:239.

Garcia Zepeda, C.M., C.L. Kastner, D.H. Kropf, M.C. Hunt, P.B. Kenney, J.R. Schwenke and D.S. Schleusener. 1993. Utilization of surimi-like products from pork with sex-odor in restructured, precooked pork roasts. *J. Food Sci.* 58:53.

Hague, M.A., K.E. Warren, M.C. Hunt, D.H. Kropf, C.L. Kastner, S.L. Stroda, and D.E. Johnson. 1994. Endpoint temperature, internal cooked color, and expressible juice color relationships in ground beef patties. *J. Food Sci.* 59:465-470.

Letelier, V., C.L. Kastner, P.B. Kenny, D.H. Kropf, M.C. Hunt, and C.M. Garcia Zepeda. 1995. Flaked sinew addition to low-fat cooked salami. *J. Food Sci.* 60:245-249.

Lavelle, C., M.C. Hunt, and D.H. Kropf. 1995. Display Life and Internal Cooked Color of Ground Beef from Vitamin E-Supplemented Steers. *J. Food Sci.* 60:1-4,6.

Sørheim, O., D.H. Kropf, M.C. Hunt, M.T. Karwoski, and K.E. Warren. 1996. Effects of modified gas atmosphere packaging on pork loin colour, display life and drip loss. *Meat Sci.* 43:203-212.

Campbell, R.E. and M.C. Hunt. 1996. Yields, chemical composition, and value of beef shank tissues obtained using Baader processing. *J. Anim. Sci.* 74:786-789.

Warren, K.E., M.C. Hunt, D.H. Kropf, M.A. Hague, C.L. Waldner, S.L. Stroda, and C.L. Kastner. 1996. Chemical properties of ground beef patties exhibiting normal and premature brown internal cooked color. *J. Muscle Foods.* 7:303-314.

Warren, K.E., M.C. Hunt, and D.H. Kropf. 1996. Myoglobin oxidative state affects internal cooked color development of ground beef patties. *J. Food Sci.* 61:513-515,519.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, M.C. Hunt, J.L. Marsden, E.J. Rubio Canas, C.L. Kastner, W.G. Kuecker, and T. Mata. 1996. Color and oxidative rancidity of gamma and electron beam-irradiated boneless pork chops. *J. Food Sci.* 61:1000-1005,1093.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, E. Chambers IV, M.E. Hollingsworth, M.C. Hunt, J.L. Marsden, C.L. Kastner, and W.G. Kuecker. 1996. Sensory analysis and consumer acceptance of irradiated boneless pork chops. *J. Food Sci.* 61:1261-1266.

Campbell, R.E., M.C. Hunt, D.H. Kropf, and C.L. Kastner. 1996. Low-fat ground beef from desinewed shanks with reincorporation of processed sinew. *J. Food Sci.* 61:1285-1288.

Luchsinger, S.E., D.H. Kropf, E. Chambers IV, C.M. Garcia Zepeda, M.C. Hunt, S.L. Stroda, M.E. Hollingsworth, J.L. Marsden, and C.L. Kastner. 1997. Sensory analysis of irradiated ground beef patties and whole muscle beef. *J. Sensory Studies.* 12:105-126.

Garcia Zepeda, C.M., C.L. Kastner, J.R. Wolf, J.E. Boyer, D.H. Kropf, M. C. Hunt and C.S. Setser. 1997. Extrusion and low-dose irradiation effects on destruction of *Clostridium sporogenes* spores in a beef-based product. *J. Food Prot.* 60:777-785.

Carmack, C.F., C.L. Kastner, M.C. Hunt, D.H. Kropf, C.M. Garcia Zepeda, and J.R. Schwenke. 1997. Sensory, chemical, and physical evaluation of reduced fat ground beef patties with "natural" flavorings. *J. Muscle Foods.* 8:199-212.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, M.C. Hunt, S.L. Stroda, J.L. Marsden, and C.L. Kastner. 1997. Color and oxidative properties of irradiated whole muscle beef. *J. Muscle Foods.* 8:427-443.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, M.C. Hunt, S.L. Stroda, J.L. Marsden, and C.L. Kastner. 1997. Color and oxidative properties of irradiated ground beef patties. *J. Muscle Foods.* 8:445-464.

Hunt, M.C., O. Sørheim, and E. Slinde. 1999. Color and heat denaturation of myoglobin forms in ground beef. *J. Food Sci.* 64:847-851.

Powell, T.H., M.C. Hunt, and M.E. Dikeman. 1999. Enzymatic assay to determine collagen thermal denaturation and solubilization. *Meat Sci.* 54:307-311

Powell, T.H., M.E. Dikeman, and M.C. Hunt. 2000. Tenderness and collagen composition of beef semitendinosus roasts cooked by conventional convective cooking and modeled, multi-stage, convective cooking. *Meat Sci.* 55:421-425.

Killinger, K.M., M.C. Hunt, and R.E. Campbell. 2000. Factors affecting premature browning during cooking of ground beef purchased at retail. *J. Food Sci.* 65:585-587.

Campbell, R.G., M.C. Hunt, P. Levis, and E. Chambers IV. 2000. Dry-aging effects on palatability of beef strip loins. *J. Food Sci.* Accepted.

Campbell, R.G., M.C. Hunt, P. Levis, and E. Chambers IV. 2000. Dry-aging effects on palatability of beef strip loins. *J. Food Sci.* In Press.

Sammel, L.M., M.C. Hunt, D.H. Kropf, K.A. Hachmeister, C.L. Kastner, and D.E. Johnson. 2001. Influence of chemical characteristics of beef inside and outside semimembranosus on color traits. *J. Food Sci.* In Press.

Sammel, L.M., M.C. Hunt, D.H. Kropf, K.A. Hachmeister, C.L. Kastner, and D.E. Johnson. 2001. Comparison of assays for metmyoglobin reducing ability in beef inside and outside semimembranosus. *J. food Sci.* In Review.

Yancey, E.J., M.C. Hunt, M.E. Dikeman, P.B. Addis, and E. Katsanidis. 2001. Effects of postexsanguination vascular infusion of cattle with a solution of saccharides, sodium chloride, phosphates, and vitamins C, E, or C+E on meat display-color stability. *J. Anim. Sci.* In Press.

Lien, R., M.C. Hunt, S. Anderson, D.H. Kropf, T.M. Loughin, M.E. Dikeman, and J. Velazco. 2001. Effects of endpoint temperature on the internal color of pork patties of different myoglobin form, initial cooking state and quality. *J. Food Sci.* In Review.

Lien, R., M.C. Hunt, S. Anderson, D.H. Kropf, T.M. Loughin, M.E. Dikeman, and J. Velazco. 2001. Effects of endpoint temperature on the internal color of pork loin chops of different quality. *J. Food Sci.* In Review.

Lawrence, T., M.C. Hunt, and D.H. Kropf. 2001. Surface roughening of pre-cooked, cured beef round muscles reduces iridescence. *J. Muscle Foods.* In Review.

#### Abstracts / Posters

Hunt, M.C., R.A. Smith, D.H. Kropf and H.J. Tuma. 1969. Factors affecting showcase color stability of frozen lamb in transparent film. *J. Anim. Sci.* 29:123. (Abstr.).

Kropf, D.H., M.C. Hunt and A.D. Dayton. 1970. Reflectance spectrophotometry for following frozen beef and lamb color changes. *J. Anim. Sci.* 31:185. (Abstr.).

Kropf, D.H., H.J. Tuma, J.A. Santamaria, M.C. Hunt and D.E. Schafer. 1971. Display light intensity effects on frozen beef color stability. *J. Anim. Sci.* 33:219. (Abstr.).

Hunt, M.C. and H.B. Hedrick. 1973. Properties of bovine longissimus muscle from four quality groups. *J. Anim. Sci.* 37:263. (Abstr.).

Allen, D.M., M.C. Hunt, C.L. Kastner, D.H. Kropf, V. Chen, A. Harrison and M.E. Smith. 1976. Improving grass-fed beef quality. *J. Anim. Sci.* 43, 236 (Abstr.).

Kuntapanit, C., B.E. Brent, M.C. Hunt, C.L. Kastner and D.H. Kropf. 1978. Fluorometric TBA analysis for muscle food autoxidation. *J. Anim. Sci. Abstr.* 13.

Harrison, R.A., M.E. Smith, D.M. Allen, M.C. Hunt, C.L. Kastner and D.H. Kropf. 1978. Nutritional regimen effects on quality and yield characteristics of beef. *Ann. Meeting Amer. Soc. Anim. Sci. Abstr.* 172.

Harrison, A.R., D.H. Kropf, D.M. Allen, M.C. Hunt and C.L. Kastner. 1978. Nutritional regimen, vacuum packaging and display length effects on color of four beef muscles. *Ann. Meeting Amer. Soc. Anim. Sci. Abstr.* 173.

Corte, O., D.M. Allen, B.E. Brent, M.C. Hunt, C.L. Kastner and D.H. Kropf. 1978. Longissimus and biceps femoris collagen characteristics of beef finished on four nutritional regimens. *Ann. Meeting Amer. Soc. Anim. Sci. Abstr.* 163.

Fung, D.Y.C., C.L. Kastner, M.C. Hunt, M.E. Dikeman and D.H. Kropf. 1979. Mesophilic and psychrotrophic populations of hot-boned and conventionally processed beef. 39th Ann. Meeting of IFT, St. Louis, MO. (Abstr.).

Harrison, A.R., D.H. Kropf, D.M. Allen, M.C. Hunt and C.L. Kastner. 1979. Nutritional regimen, vacuum packaging and display length effects on color of four beef muscles. 39th Ann. Meeting of IFT, St. Louis, MO. (Abstr.).

Harrison, A.R., D.H. Kropf, D.M. Allen, M.C. Hunt and C.L. Kastner. 1979. Relationship of various spectrophotometric reflectance measurements to beef muscle visual color. 39th Ann. Meeting of IFT, St. Louis, MO. (Abstr.).

Hayward, L.H., M.C. Hunt, D.M. Allen, C.L. Kastner and D.H. Kropf. 1979. Blade tenderization effects on beef longissimus sensory, and Instron textural measurements. 39th Ann. Meeting of IFT, St. Louis, MO. (Abstr.).

Francis, S., D. Allen and M.C. Hunt. 1980. Animal agriculture and consumers. J. Anim. Sci. Midwest ASAS (Abstr.).

Obanion, D.S., R.R. Schalles and M.C. Hunt. 1980. Relationship among performance of yearling bulls and longissimus amino acids and histochemical characteristics. J. Anim. Sci. Midwest ASAS (Abstr.).

Hunt, M.C., J.L.A. Kendall, M.E. Dikeman, C.L. Kastner and D.H. Kropf. 1980. Ground beef from electrically stimulated and hot-boned carcasses. 13th Ann. Meeting Midwestern Sec. of Amer. Soc. Anim. Sci. Abstr. 30.

Wu, J.J., D.M. Allen, M.C. Hunt, C.L. Kastner and D.H. Kropf. 1980. Nutritional effects on beef palatability and collagen characteristics. 13th Ann. Meeting Midwestern Sec. of Amer. Soc. Anim. Sci. Abstr. 33.

Kastner, C.L., M.E. Dikeman, K.N. Nägele, M. Lyon, M.C. Hunt and D.H. Kropf. 1980. Effects of carcass electrical stimulation and hot boning on selected beef muscles. Proc. European Meeting of Meat Res. Workers. Abstr. 26:I-2, 40.

Lyon, M., C.L. Kastner, M.E. Dikeman, M.C. Hunt, D.H. Kropf and J.R. Schwenke. 1980. Beef carcass electrical stimulation and hot boning effects on psoas major and triceps brachii muscles. Proc. Recip. Meat Conf., 33:85. (Abstr.).

Hale, D.S., M.C. Hunt and C.L. Kastner. 1981. Fiber orientation effects on Warner-Bratzler shear values. 14th Ann. Meeting Midwestern Sec. of Amer. Soc. of Anim. Sci. (Abstr.).

Lyon, M., C.L. Kastner, M.E. Dikeman, M.C. Hunt, D.H. Kropf and J.R. Schwenke. 1981. Beef carcass electrical stimulation and hot boning effects on psoas major and triceps brachii muscles. 14th Ann. Meeting Midwestern Sec. of Amer. Soc. of Anim. Sci. (Abstr.).

Claus, J.R., D.H. Kropf, M.C. Hunt, C.L. Kastner and M.E. Dikeman. 1981. Muscle color display life as influenced by electrical stimulation and hot boning. J. Anim. Sci. 53 (Suppl. 1):210.

Dikeman, M.E., S.C. Olsen, C.L. Kastner and M.C. Hunt. 1981b. Conventional versus accelerated beef production and processing. II. J. Anim. Sci. 53 (Suppl. 1):212.

Greathouse, J.R., M.C. Hunt, M.E. Dikeman and L.R. Corah. (1982). Effects of zeranol implants on performance and carcass characteristics of bulls implanted from birth to slaughter. J. Anim. Sci. 55 (Suppl. 1):240.

Dikeman, M.E., J.R. Greathouse, M.C. Hunt, C.L. Kastner, P.S. Sleper, D.H. Kropf and L.R. Corah. 1982. Effects of zeranol implants and electrical stimulation on palatability of bulls implanted from birth to slaughter. II. J. Anim. Sci. 55 (Suppl. 1):238.

Hunt, M.C., P.S. Sleper, D.H. Kropf, M.E. Dikeman and C.L. Kastner. 1982. Myoglobin properties of electrically stimulated bull longissimus muscle. J. Anim. Sci. 55 (Suppl. 1):242.

Rao, B.R., D.H. Kropf, C.L. Kastner, M.E. Dikeman and M.C. Hunt. 1982. Influence of freezing temperatures and storage time on aroma and flavor of ground beef. *J. Anim. Sci.* 55 (Suppl. 1):255.

Burson, D.E., M.C. Hunt, D.E. Schafer and D. Beckwith. (1982). Stunning method and time interval to sticking effects on blood splashing in pork. *J. Anim. Sci.* 55 (Suppl. 1):233.

Shivas, S.D., D.H. Kropf, C.L. Kastner, J.L.A. Kendall, M.C. Hunt and A.D. Dayton. 1982. Effects of ascorbic acid on display life of ground beef. *Internat'l. Symp. Meat Science and Technol.*, Lincoln, Nebraska, Nov. 1982.

Burson, D.E., M.C. Hunt, D.E. Schafer, D. Beckwith and J.R. Garrison. 1982. Stunning method and time interval from stunning to exsanguination effects on blood splashing in pork. *Internat'l. Symp. Meat Science and Technol.*, Lincoln, Nebraska, Nov. 1982.

Greathouse, J.R., M.C. Hunt, M.E. Dikeman, L.R. Corah, C.L. Kastner and D.H. Kropf. 1982. Ralgro implanted bulls: performance, carcass, characteristics and longissimus palatability. *Internat'l. Symp. Meat Science and Technol.*, Lincoln, Nebraska, Nov. 1982.

Hunt, M.C., P.S. Sleper, D.H. Kropf, C.L. Kastner and M.E. Dikeman. 1982. Electrical stimulation effects on myoglobin characteristics. *Internat'l. Symp. Meat Science and Technol.*, Lincoln, Nebraska, Nov. 1982.

Fung, D.Y.C., Fung, C-Y Lee, C.L. Kastner, M.E. Dikeman, M.C. Hunt and D.H. Kropf. 1982. Microbiology of hot-boned beef. *Internat'l. Symp. Meat Science and Technol.*, Lincoln, Nebraska, Nov. 1982.

Shivas, S.D., C.L. Kastner, M.E. Dikeman, M.C. Hunt and D.H. Kropf. 1983. Effects of electrical stimulation, hot boning and chilling rate on bull semimembranosus muscle. *J. Anim. Sci.* 57 (Suppl. 1):231.

Choi, Y.I., C.L. Kastner, M.E. Dikeman, M.C. Hunt and D.H. Kropf. 1983. Effects of electrical stimulation and hot boning on functional characteristics of preblended beef muscle in model system. *Proc. Recip. Meat Conf.* 36:190.

Unruh, J.A., C.L. Kastner, D.H. Kropf, M.E. Dikeman and M.C. Hunt. 1984. Effects of low voltage electrical stimulation during exsanguination on characteristics of beef longissimus and semimembranosus muscles. *J. Anim. Sci.* 59 (Suppl. 1):90.

Kropf, D.H., C.M. Jaunsolo, M.E. Dikeman, M.C. Hunt and C.L. Kastner. 1984. Display color stability of vacuum packaged rib steaks from bulls and zeranol implanted bulls and steers. *J. Anim. Sci.* 59 (Suppl. 1):234.

Hunt, M.C., C.M. Jaunsolo, D.H. Kropf, C.L. Kastner and M.E. Dikeman. 1984. Correlation of reflectance measurements to visual color for frozen and unfrozen skin-tight packaged beef longissimus. *J. Anim. Sci.* 59 (Suppl. 1):234.

Unruh, J.A., C.L. Kastner, D.H. Kropf, M.E. Dikeman and M.C. Hunt. 1984. Effect of low voltage electrical stimulation during exsanguination on characteristics of beef longissimus and semimembranosus muscles. *Proc. Recip. Meat Conf.* 37:180.

Burson, D.E. and M.C. Hunt. 1985. Heat-induced changes on the proportion of types I and III collagens in bovine longissimus. *J. Anim. Sci.* 61 (Suppl. 1):94.

Hunt, M.C. and D.E. Burson. 1985. Proportion of types I and III collagens in four bovine muscles. *Ann. Meeting of IFT*, Atlanta, GA (Abstr.) #340.

Burson, D.E., M.C. Hunt, J.A. Unruh and M.E. Dikeman. 1985. Proportions of types I and III collagen in intramuscular collagen of bulls and steers. *J. Anim. Sci.* 61 (Suppl. 1):94.

Dikeman, M.E., T. Timmis, M.C. Hunt, R.H. Hines, G. Highfill and J.S. Stevenson. 1985. Effects of Compudose 2000 implants on performance, carcass, meat quality traits and serum testosterone in young boars. *J. Anim. Sci.* 61 (Suppl. 1):279.

Hunt, M.C., M.E. Dikeman, G.A. Highfill, R.H. Hines and T. Timmis. 1985. Effects of sex and CompuDose 2000 implantation on porcine longissimus and semimembranosus histochemistry. *J. Anim. Sci.* 61 (Suppl. 1):282.

Kluber, III, E.F., J.S. Stevenson, D.L. Davis, M.C. Hunt, J.E Minton and J.L. Nelssen. 1986. Growth, carcass, sexual and boar odor traits of growing male pigs fed altrenogest. *J. Anim. Sci.* 63(Suppl. 1):85.

Allen, D.M., A. Luchiari Filho and M.C. Hunt. 1986. Effects of spray versus conventional chilling of beef carcasses and cut yields and USDA grade factors. *J. Anim. Sci.* 63(Suppl. 1):254.

Claus, J.R., S.J. Goll, M.C. Hunt, G.A. Whipple and E.S. Wright. 1987. Meat Science at Kansas State University. *Proc. Recip. Meat Conf. Teaching Display.*

Johnson, R.D., M.C. Hunt, D.M. Allen, C.L. Kastner and C.C. Schrock. 1988. Effects of carcass washing and length of spray cycle during chilling on surface fat and lean moisture contents on weight yields of holstein and beef steer carcasses. *J. Anim. Sci.* 66 (Suppl. 1):124.

Goll, S.J., C.L. Kastner, M.C. Hunt and D.H. Kropf. 1988. Effects of glucose and internal cooking temperature on the characteristics of low fat, pre- and post-rigor, restructured beef roasts. *J. Anim. Sci.* 66 (Suppl. 1):126.

Claus, J.R. and M.C. Hunt. 1988. Processed meats with reduced caloric density. Kansas State University Cattlemen's Day.

Claus, J.R. and M.C. Hunt. 1988. Low-fat processed meats. Kansas Agric. Exp. Conference.

Hunt, M.C. 1988. Spray chilling of beef carcasses. Kansas Agric. Exp. Conference.

Goll, S.J., C.L. Kastner, M.C. Hunt and D.H. Kropf. 1988. Value added, restructured beef products. Kansas Agric. Exp. Conference.

Whipple, G., M.C. Hunt, R.D. Klemm, D.H. Kropf, R.D. Goodband, J.L. Nelssen, R.H. Hines and B.R. Schricker. 1989. Effects of porcine somatotropin and supplemental lysine on porcine muscle histochemistry. *J. Anim. Sci.* 67(Suppl. 1):161.

Whipple G., M. Koohmaraie, M.E. Dikeman, J.D. Crouse, M.C. Hunt and R.D. Klemm. 1989. Evaluation of attributes that affect longissimus muscle tenderness in Bos taurus and Bos indicus cattle. *Proc. Recip. Meat Conf.* 42:

Nold, R.A., J.A. Unruh, C.W. Spaeth, J.E. Minton and M.C. Hunt. 1990. Effect of implanting zeranol at birth and weaning on performance, pelting, carcass and subprimal yield characteristics of ram and wether lambs. *J. Anim. Sci.* 68(Suppl. 1):93.

Kenney, P.B. and M.C. Hunt. 1990. Effect of water and salt content on protein solubility and water retention of meat preblends. *J. Anim. Sci.* 68(Suppl. 1):61.

Hunt, M.C., E.S. Troutt, D.E. Johnson, J.R. Claus, C.L. Kastner, D.H. Kropf and S. Stroda. 1990. Low-fat ground beef: physical, chemical and sensory characteristics. *J. Anim. Sci.* 68(Suppl. 1):327.

Hunt, M.C. and J.R. Claus. 1990. Effect of texture modifying ingredients on characteristics of low-fat, high-added water bologna. *J. Anim. Sci.* 68(Suppl. 1):350

Warren, K.E., M.C. Hunt, C.L. Marksberry, O. Sorheim and D.H. Kropf. 1990. Modified atmosphere packaging with 100% carbon dioxide for bone-in pork loins. *J. Anim. Sci.* 68(Suppl. 1):351

Wang, H., D.H. Kropf, M.C. Hunt, and C.L. Kastner. 1990. Causes of iridescence in precooked beef. 49th Ann. Meeting of IFT, Dallas, TX (Abstr.)

Nold, R.A., J.A. Unruh, C.W. Spaeth, J.E. Minton and M.C. Hunt. 1991. Effect of implanting ram and wether lambs with zeranol at birth and weaning on palatability and muscle collagen characteristics. *J. Anim. Sci.* 69(Suppl. 1):63.

Zepeda, Garcia C.M., C.L. Kastner, D.H. Kropf, M.C. Hunt, P.B. Kenney, J.R. Schwenke, and D.S. Schluesener. 1991. Utilization of surimi-like products from pork with sex odor in restructured, precooked pork roasts. *J. Anim. Sci.* 69(Suppl. 1):97.

Kropf, D.H., O. Sorheim, M.C. Hunt, K.E. Warren and M. Menninen. 1991. Modified atmosphere packaging and carcass chill effects on pork loins. *J. Anim. Sci.* 69(Suppl. 1):337.

Brester, G.W., P. Lhermite, B.K. Goodwin and M.C. Hunt. 1992. Quantifying the effects of new product development: The case of low-fat ground beef. *Amer. Agric. Econ. Assoc. Annual Meeting.(Abstr.)*

Payne, C.A., M.C. Hunt, K.E. Warren, J.M. Hayden, J.E. Williams and H.B. Hedrick. 1992. Effects of nutrition on histochemical characteristics of four bovine muscles differing in growth impetus. *J. Anim. Sci.* 70(Suppl. 1):221.

Warren, K.E., C.A. Payne, M.C. Hunt, G. Whipple, M. Koohmaraie, J. Hayden, J. Williams and H.B. Hedrick. 1992. Carcass composition, protease activity, shear force, and myofibrillar fragmentation index of longissimus thoracis muscle from crossbred steers as influenced by dry-matter intake. *J. Anim. Sci.* 70(Suppl. 1): 221.

Hague, M.A., K.E. Warren, M.C. Hunt, D.H. Kropf and S.L. Stroda. 1992. Relationship between endpoint temperature, internal cooked color, and expressible juice color of ground beef patties made from imported trimmings and A- and D/E-maturity lean. *J. Anim. Sci.* 70(Suppl. 1):225.

Payne, C.A., M.C. Hunt, K.E. Warren, J.M. Hayden, J.E. Williams and H.B. Hedrick. 1992. Histochemical properties of four bovine muscles as influenced by compensatory gain and growth impetus. *Proc. Internat'l. Congress Meat Sci. and Technol.* 38:121.

Kropf, D., H. Wang, M. Hunt and C. Kastner. 1992. Causes and solutions of iridescence in precooked meat. *Proc.*

Hunt, M.C. and R.E. Campbell. 1992. Lean, fat, and connective tissue from beef shanks processed with a Baader

Warren, K.E., M.C. Hunt, M.A. Hague, D.H. Kropf, S.L. Stroda and D.E. Johnson. 1993. Inconsistencies in expressible juice and internal cooked color of ground beef patties. *J. Anim. Sci.* 71(Suppl. 1):50.

Warren, K.E., M.C. Hunt, C.A. Payne, E.S. Troutt, A.E. Boyle, D.H. Kropf and D.E. Johnson. 1993. Investigation of the color stability of commercial pizza pepperoni during lighted display. *J. Anim. Sci.* 71(Suppl. 1):50.

Campbell, R.E. and M.C. Hunt. 1993. Value-added processing of beef shanks by Baader desinewing. *J. Anim. Sci.* 71(Suppl. 1):51.

Payne, C.A., M.C. Hunt and P.A. Seib. 1993. Effects of native and phosphate-modified starch on the yield and texture of ground beef.

Warren, K.E., M.C. Hunt, D.H. Kropf, S.J. Smith, and S.L. Stroda. 1993. Chemical Characterization of ground beef.

Osburn, W.N., J.T. Keeton and M.C. Hunt. 1993. Utilization of konjac flour in low-fat, precooked lamb sausages. *J. Anim. Sci.* 71(Suppl. 1):51.

Esquivel, O., D.H. Kropf, M.C. Hunt and J.R. Schwenke. 1993. Effect of texturizers on low-fat fermented hard beef salami. *Ann. Meeting Inst. Food Tech.*

Marksberry, C.L., D.H. Kropf, M.C. Hunt and C.L. Kastner. 1994. The effect of fat level, pH, and carcass maturity on the cooked internal color of ground beef patties at five end-point temperatures. *Ann. Meeting Inst. Food Tech.*

Powell, T.H. and M.C. Hunt. 1994. Enzymatic collagen analysis determines heat-altered and solubilized collagen in cooked meat. *Ann. Meeting Inst. Food Tech.*

Warren, K.E., M.C. Hunt, D.H. Kropf and C.L. Kastner. 1994. Chemical properties of ground beef patties exhibiting normal and premature brown internal cooked color. *Ann. Meeting Inst. Food Tech.*

Warren, K.E., M.C. Hunt and D.H. Kropf. 1994. Myoglobin oxidative state affects internal cooked color development of ground beef patties. Ann. Meeting Inst. Food Tech.

Payne, C.A., M.C. Hunt, P.A. Seib, D.H. Kropf and C.L. Kastner. 1994. Evaluation of commercial starches in a model meat batter system containing low-fat/high addend water. Ann Meeting Inst. Food Tech.

Marksberry, C.L., D.H. Kropf, M.C. Hunt and C.L. Kastner. 1994. The effect of fat level, pH, and carcass maturity of the cooked internal color of ground beef patties at five end-point temperatures. Ann. Meeting Inst. Food Tech.

Payne, C.A., M.C. Hunt, P.A. Seib, D.H. Kropf and C.L. Kastner. 1994. Evaluation of commercial starches in a

Warren, K.E., M.C. Hunt, D.H. Kropf and C.L. Kastner. 1994. Chemical properties of ground beef patties exhibit

Warren, K.E., M.C. Hunt and D.H. Kropf. 1994. Myoglobin oxidative state affects internal cooked color development of ground beef patties. Ann. Meeting Inst. Food Tech.

Hunt, M.C., C.A. Payne and P.A. Seib. 1994. Properties of low-fat, high added-water beef sausages containing pt

Hunt, M.C., K.E. Warren, D.H. Kropf, M.A. Hague, C.L. Waldner, S.L. Stroda, and C.L. Kastner. 1994. Factors affecting premature browning in cooked ground beef. Internatl. Cong. Meat Sci. & Technol. Netherlands.

McCart, V.E., R.K. Phebus, D.Y.C. Fung, and M.C. Hunt. 1995. Effects of fat level and fat replacement in ground beef on the survival of *Listeria monocytogenes* and *Escherichia coli* O157:H7 during storage and cooking. Ann. Meeting Inst. Food Tech.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, J.L. Marsden, S.L. Stroda, M.C. Hunt, E. Chambers IV, M. Hollingsworth, and C.L. Kastner. 1995. Palatability, color and product life of low-dose irradiated precooked ground beef. Proc. Internatl. Cong. Meat Sci. & Technol. 41:224-225.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, J.L. Marsden, S.L. Stroda, M.C. Hunt, E. Chambers IV, M. Hollingsworth, and C.L. Kastner. 1995. Palatability, color and product life of low-dose irradiated beef steaks. Proc. Internatl. Cong. Meat Sci. & Technol. 41:272-273.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, J.L. Marsden, S.L. Stroda, M.C. Hunt, E. Chambers IV, M. Hollingsworth, and C.L. Kastner. 1995. Palatability, color and product life of low-dose irradiated raw ground beef. Proc. Internatl. Cong. Meat Sci. & Technol. 41:278-279.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, J.L. Marsden, S.L. Stroda, E.J. Rubio Canas, M.C. Hunt, E. Chambers IV, M. Hollingsworth, and C.L. Kastner. 1995. Sensory analysis and consumer acceptance of low-dose irradiated boneless pork chops. Proc. Internatl. Cong. Meat Sci. & Technol. 41:416-417.

Hunt, M.C., O. Sørheim, and E. Slinde. 1995. Effects of myoglobin form on internal cooked color development in ground beef. Proc. Internatl. Cong. Meat Sci. & Technol. 41:394-395.

Lavelle, C.L., M.C. Hunt, and D.H. Kropf. 1995. Expressible juice and internal cooked color of ground beef patties from vitamin E-supplemented steers. Proc. Internatl. Cong. Meat Sci. & Technol. 41:396-397.

Lavelle, C.L., M.C. Hunt and D.H. Kropf. 1995. Display life and internal cooked color of ground beef from vitamin E supplemented cattle. Ann. Meeting Inst. Food Tech.

Hunt, M.C. and T.H. Powell. 1995. Physical properties of cooked meat--color and texture. Ann. Meeting Inst. Food Tech.

Kropf, D.H., M.C. Hunt, O. Sørheim, K.E. Warren, C.L. Waldner, and F.W. Pohlman. 1995. Modified atmosphere packaging on the color of fresh and frozen muscle foods. Ann. Meeting Inst. Food Tech.

Kropf, D.H., M.C. Hunt, S.E. Luchsinger, C.M. Garcia Zepeda, E. Chambers IV, J.L. Marsden, M.E. Hollingsworth, S.L. Stroda, E.J. Rubio Canas, and C.L. Kastner. 1995. Sensory analysis, color, and product

life of low-dose irradiated beef and pork. In Activities Report of the Research and Development Associates for Military Food and Packaging Systems. 48 (1): 327-345.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, E. Chambers IV, M.E. Hollingsworth, M.C. Hunt, J.L. Marsden, S.L. Stroda, E.J. Rubio Canas, C.L. Kastner, W.G. Kuecker, and T. Mata. 1996. Consumer acceptance of irradiated boneless pork chops. Abst. of Institute of Food Technologists Annual Meeting.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, E. Chambers IV, M.E. Hollingsworth, M.C. Hunt, J.L. Marsden, S.L. Stroda, E.J. Rubio Canas, C.L. Kastner, W.G. Kuecker, and T. Mata. 1996. Sensory analysis, color, and product life of irradiated boneless pork chops. Abst. of Institute of Food Technologists Annual Meeting.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, J.L. Marsden, S.L. Stroda, M.C. Hunt, E. Chambers IV, M.E. Hollingsworth, and C.L. Kastner. 1996. Sensory analysis, color, and product life of irradiated frozen raw ground beef patties. Abst. of Institute of Food Technologists Annual Meeting.

Luchsinger, S.L., D.H. Kropf, and M.C. Hunt. 1996. Irradiation studies on meat. Proc. Res. on Salmonellosis in the Food Safety Consortium. U.S. Animal Health Assoc., Little Rock, AR.

Venkat, V., M.C. Hunt, and D.H. Kropf. 1997. Photographic guidelines for pork display color. Proc. Reciprocal Meat Conf. 50:167.

Henderson, L. and M.C. Hunt. 1997. Multimedia distance learning. Proc. Reciprocal Meat Conf. 50.

Kropf, D.H. and M.C. Hunt. 1998. Endpoint cooking temperature and meat color. Proc. Reciprocal Meat Conf. 51:144-148.

Clark, T.J., M.C. Hunt, D.H. Kropf, and G.R. DelDuca. 1998. Rebloom and display color stability of beef packaged in and untra-low oxygen modified atmosphere system. Proc. Reciprocal Meat Conf. 51:185.

Schoenbeck, J.J., M.C. Hunt, T.E. Dobbels, M.E. Dikeman, and S.L. Stroda. 1998. Display color stability of steaks and ground beef from carcasses cardiovascularily infused immediately after exsanguination. Proc. Reciprocal Meat Conf. 51:186.

Killinger, K.M., M.C. Hunt, and R.E. Campbell. 1998. Incidence of premature browning in ground beef patties purchased at retail. Proc. Reciprocal Meat Conf. 51:185.

Schoenbeck, M.K., D.H. Kropf, M.C. Hunt, J.S. Pontius, S.L. Stroda, and S. Hawthorne. 1998. The effects of pH, myoglobin form and endpoint temperature on cooked ground beef color. Proc. Reciprocal Meat Conf. 51:186.

Venkat, V.R., M.C. Hunt, and D.H. Kropf. 1998. Photographic guidelines for pork display color stability. Ann. Meeting Inst. Food Tech.

Campbell, R.E. and M.C. Hunt. 1998. Sensory and physical characteristics of dry-aged beef strip steaks. Ann. Meeting Inst. Food Tech.

Hawthorne, S.A., R. Lien, M.C. Hunt, D.H. Kropf, and M. Hardin. 1999. Effects of endpoint temperature on internal cooked color development in ground pork and loin chops. Ann. Meeting Inst. Food Tech.

Hunt, M.C., S.A. Hawthorne, R. Lien, D.H. Kropf, and M. Hardin. 1999. Factors affecting the denaturation of myoglobin in ground pork patties. Proc. 45<sup>th</sup> Internat'l. Congress Meat Sci. and Technol.

Dikeman, M.E., T.E. Dobbels, J.J. Schoenbeck, and M.C. Hunt. 1999. Effects of vascular infusion of cattle after exsanguination with a solution of saccharides, sodium chloride, and phosphates or with calcium chloride on carcass traits and meat palatability. J. Anim. Sci. 77 (Suppl. 1):77:23.

Yancey, E.J., M.C. Hunt, M.E. Dikeman, T.E. Dobbels, and P.B. Addis. 1999. Effects of vascular infusion of cattle after exsanguination with saccharides, sodium chloride, and phosphates plus vitamin C, E, or C+E on meat display color stability. J. Anim. Sci. 77 (Suppl. 1):77:172.

Hachmeister, K.A., D.H. Kropf, J.L. Marsden, V.S. Gill, C.L. Kastner, and M.C. Hunt. 1999. Sensory analysis of electron beam pasteurized ground beef patties. Proc. New Mexico Environmental Health Conf. Albuquerque.

Dikeman, M.E., T.E. Dobbels, M.C. Hunt, and J.J. Schoenbeck. 1999. Effects of post-bleeding vascular injection of cattle with a solution of sugars, sodium chloride, and phosphates or calcium chloride on carcass traits and meat palatability. Kansas Agr. Ep. Sta. Rep. of Prog. No 831:17-20.

Hachmeister, K.A., D.H. Kropf, J.L. Marsden, V.S. Gill, C.L. Kastner, M.C. Hunt, and R.J. Kaye. 1999. Thiamin and riboflavin retention of electron beam pasteurized ground beef patties. Proc. Ann. Meeting Food Safety Consortium. p. 167.

Hachmeister, K.A., D.H. Kropf, J.L. Marsden, V.S. Gill, R.J. Kaye, C.L. Kastner, and M.C. Hunt. 1999. Effects of repetitive high energy pulsed power (RHEPP) irradiation on sensory attributes, color, and shelf life of ground beef. Kansas Agr. Ep. Sta. Rep. of Prog. No 831:1-3.

Hawthorne, S.A., R. Lein, M.C. Hunt, and D.H. Kropf. 1999. Ground pork cooked color guide. Kan. Ag. Exp Stat.

Hawthorne, S.A., R. Lein, M.C. Hunt, and D.H. Kropf. 1999. Pork chop cooked color guide. Kan. Ag. Exp Stat.

Hawthorne, S.A., M.C. Hunt, D.H. Kropf, and R. Lien. 1999. Effects of endpoint temperature on internal cooked color development in ground pork and loin chops. Proc. Ann Meeting Food Safety Consortium. p. 187.

Slinde, Erik, Melvin Hunt and Oddvin Sorheim. 2000. Effects of myoglobin from on colour and heat denaturation of ground beef. Proc. 35<sup>th</sup> Norwegian Biochemical Contact Meeting. Tromso Norway. Abstract no. 4.

Ceylan, E., D.Y.C. Fung, M.C. Hunt and C.L. Kastner. 2000. Synergistic effects of garlic and heating in controlling *Escherichia coli* 0157:H7 in ground beef patties. Ann. Meeting Inst. Food Tech.

Ceylan, E., D.Y.C. Fung, M.C. Hunt and C.L. Kastner. 2000. Synergistic effects of garlic and heating in controlling *Escherichia coli* 0157:H7 in ground beef patties. Proc. Ann. Meeting Food Safety Consortium. p.

Kropf, D.H. and M.C. Hunt. 2000 Shelf-life attributes of retail meat and poultry. Symposium: Factors influencing the Successful Implementation of Centralized Packaging of Meat and Poultry. Inst. Food Technologist Annual Meeting, Dallas TX, June 10-14.

Lehmuller, Peter and Melvin Hunt. 2000 Perception of degrees of doneness of beef by professional chefs. Proc Reciprocal Meat Conf. 53:133.

Conference Proceedings, Symposia, Books, etc.

Kropf, D.H., H.J. Tuma, M.C. Hunt, R.A. Smith, M.L. Sandberg, J.A. Santamaria, J.A. Fry and D.E. Schafer. 1971. Retail display case lighting. Proc. 12th Annual Meeting of Food Distribution Research Society.

Kropf, D.H., H.J. Tuma, C.C. Allen, M.C. Hunt, M.L. Sandberg and D.E. Schafer. November, 1974. Evaluation of color and other properties of frozen beef. Proc. of Symposium on Objective Methods for Food Evaluation (Sponsored by U.S. Army Natick Labs and National Research Council).

Kropf, D.H., M.C. Hunt, C.C. Allen and H.J. Tuma. 1976. Color measurement of red meat. IFT Symposium on Color measurement in foods.

Hunt, M.C. 1980. Meat color measurement. Proc. Recip. Meat Conf. 33:41.

Kastner, C.L., M.E. Dikeman, K.N. Nagele, M. Lyon, M.C. Hunt and D.H. Kropf. 1980. Effects of carcass electrical stimulation and hot boning on selected beef muscles. Proc. European Meeting of Meat Research Workers. Vol. 2. 26:40.

Hunt, Melvin C. 1981. Conversion of muscle to meat. Proc. 2nd Internatl. Course of Meat Technol. Inst. de Technologia de Alimentos, Campinas, SP-Brazil. p. 14-1.

Hunt, Melvin C. 1981. Meat emulsions. Proc. 2nd. Internatl. Course of Meat Technol. Inst. de Technologia de Alimentos, Campinas, SP-Brazil. p. 23-1.

Hunt, Melvin C. 1981. Nitrite and chemistry of cured color. Proc. 2nd Internatl. Course of Meat Technol. Inst. de Technologia de Alimentos, Campinas, SP-Brazil. p. 24-1.

Hunt, Melvin C. 1981. Tumbling, massaging and restructured meat. Proc. 2nd Internatl. Course of Meat Technol. Inst. de Technologia de Alimentos, Campinas, SP-Brazil. p. 26-1.

Kropf, D.H., C. Kuntapanit, M.C. Hunt, C.L. Kastner and B.E. Brent. 1984. Effect of vacuum aging and display on lipid oxidation of subcutaneous fat and three layers of beef longissimus. Proc. European Meat Res. Workers. 30:221.

Kropf, D.H. and M.C. Hunt. 1984. Effect of display conditions on meat products. Proc. Meat Ind. Res. Conf. p. 153.

Hunt, M.C. and D.H. Kropf. 1985. Fresh and cured meat color analyses. IFT Muscle Foods Symposium.

Kropf, D.H., M.C. Hunt and Dorly Piske. 1985. Color formation and retention in fresh meat. Proc. Meat Ind. Res. Conf. p. 62.

Hunt, M.C. and D.H. Kropf. 1987. Color and Appearance. In: Restructured Meat and Poultry Products. Adv. in Meat Research. Vol. 3, p. 125. AVI Publishing Co., Inc., Westport, CT.

Bjerklie, S. and M.C. Hunt. 1988. Practical meat photography. Proc. Recip. Meat Conf. 41:

Hunt, M.C., G.A. Highfill, M.E. Dikeman and R.H. Hines. 1988. Sex and compudose® implantation effects on porcine longissimus and semimembranous fiber types. Proc. Internatl. Congress Meat Sci. and Technology. 34:62.

Hunt, M.C. 1989. Career opportunities in meat/food science. Southern Univ. Shreveport, MS. Live, nation-wide satellite tele-video presentation. Co-sponsored by Campbells Soup Co.

Hunt, M.C., J.C. Acton, R.C. Benedict, C.R. Calkins, D.P. Cornforth, L.E. Jeremiah, D.G. Olson, C.P. Salm, J.W. Savell and S.D. Shivas. 1991. Guidelines for Meat Color Evaluation. Proc. Recip. Meat Conf. 44:232.

Payne, C.A., M.C. Hunt, K.E. Warren, J.M. Hayden, J.E. Williams and H.B. Hedrick. 1992. Histochemical properties of four bovine muscles as influenced by compensatory gain and growth impetus. Proc. Internatl. Congress Meat Sci. and Technol. 38:121.

Kropf, D., H. Wang, M. Hunt and C. Kastner. 1992. Causes and solutions of iridescence in precooked meat. Proc. Internatl. Congress Meat Sci. and Technol. 38: 515.

Hunt, M.C. and R.E. Campbell. 1992. Lean, fat, and connective tissue from beef shanks processed with a Baader desinewer. Proc. Internatl. Congress Meat Sci. and Technol. 38:1219.

Payne, T. and M. Hunt. 1993. Starch use in meat products. Proc. Midwest Meat Proc. Seminar. 22:I-1.

Hunt, M.C. and D.H. Kropf. 1993. Color measurement of meat and meat products. Proc. Recip. Meat Conf. 46:59.

Hunt, M.C. and R. E. Campbell. 1993. Spray chilling of beef and pork carcasses for weight conservation. Proc. Meat Ind. Res. Conf.

Hunt, M.C. and T.H. Powell. 1995. Physical properties of cooked meat - color and texture. Muscle Foods Symposium. Ann. Meeting Inst Food Tech.

Kropf, D.H., M.C. Hunt, K.E. Warren, M.A. Hague, C.L. Waldner, S.L. Stroda, and C.L. Kastner. 1995. Cooked ground beef color is unreliable indicator of maximum internal temperature. Amer. Chem Society Ann. Meeting, Anaheim, CA.

Lavelle, C., M.C. Hunt, and D.H. Kropf. 1995. Cooked ground beef color and safety. Proc. Meat Industry Res Conf. Amer. Meat Inst. p. 167.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, E. Chambers IV, M.E. Hollingsworth, M.C. Hunt, J.L. Marsden, S.L. Stroda, E.J. Rubio Canas, C.L. Kastner, W.G. Kuecker, and T. Mata. 1995. Consumer acceptance of low-dose irradiated boneless pork chops. In Annual Report, Swine Day, Kansas State University, p. 129-130.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, E. Chambers IV, M.E. Hollingsworth, M.C. Hunt, J.L. Marsden, S.L. Stroda, E.J. Rubio Canas, C.L. Kastner, W.G. Kuecker, and T. Mata. 1995. Flavor and aroma of low-dose irradiated boneless pork chops. In Annual Report, Swine Day, Kansas State University, p. 131-134.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, E. Chambers IV, M.E. Hollingsworth, M.C. Hunt, J.L. Marsden, S.L. Stroda, E.J. Rubio Canas, C.L. Kastner, W.G. Kuecker, and T. Mata. 1995. Display life and related traits of low-dose irradiated boneless pork chops. In Annual Report, Swine Day, Kansas State University, p. 135-138.

Luchsinger, S.E., D.H. Kropf, and M.C. Hunt. 1996. Irradiation studies on meat. Proc. Symp. Studies on Food Borne Salmonellosis. Food Safety Consortium and U.S. Public Health Assoc. Little Rock, AK.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, J.L. Marsden, S.L. Stroda, M.C. Hunt, E. Chambers IV, M.E. Hollingsworth, and C.L. Kastner. 1996. Sensory traits, color, and shelf life of irradiated beef steaks. In Annual Report, Cattleman's Day, Kansas State University, p. 4-7.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, J.L. Marsden, S.L. Stroda, M.C. Hunt, E. Chambers IV, M.E. Hollingsworth, and C.L. Kastner. 1996. Sensory traits, color, and shelf life of irradiated raw ground beef patties. In Annual Report, Cattleman's Day, Kansas State University, p. 8-10.

Luchsinger, S.E., D.H. Kropf, C.M. Garcia Zepeda, J.L. Marsden, S.L. Stroda, M.C. Hunt, E. Chambers IV, M.E. Hollingsworth, and C.L. Kastner. 1996. Sensory traits, color, and shelf life of irradiated precooked ground beef patties. In Annual Report, Cattleman's Day, Kansas State University, p. 11-13.

Kropf, D. H., S. E. Luchsinger, C.M. Garcia-Zepeda, E. Chambers, IV., and M.C. Hunt. 1996. Irradiation: A path to a safer food supply. Proc. Meat Industry Res. Conf. Amer. Meat Inst.

✓ Venkat, V., M.C. Hunt, and D.H. Kropf. 1997. Photographic guidelines for pork display color. Proc. Reciprocal Meat Conf. 50:

Luchsinger, S.E., M.C. Hunt, and D.H. Kropf. 1997. High carbon dioxide modified-atmosphere packaging (MAP) for beef steaks. Kans. Ag. Exp. Stat. Rpt. of Progress 783.

Powell, T.H., M.E. Dikeman, and M.C. Hunt. 1999. Modeled, multi-stage convection cooking of beef semitendinosus roasts to denature collagen and to optimize tenderness. Kansas Agr. Expt. Sta. Rpt. Prog. No. 831:34-36.

Hunt, M.C., J.J. Schoenbeck, M.E. Dikeman, T.E. Dobbels, and S.L Stroda. 1999. Color stability of steaks from carcasses vascularly infused immediately after exsanguination. Kansas Agr. Expt. Sta. Rep. of Prog. No. 831:21-25.

Hunt, M.C., K.M. Killinger, and R.E. Campbell. 1999. Incidence of premature browning during cooking in ground beef purchased at retail. Kansas Agr. Expt. Sta. Rpt. of Prog No. 831:11-13.

Hachmeister, K.A. D.H. Kropf, J.L. Marsden, V.S. Gill, C.L. Kastner, M.C. Hunt, and R.J. Kaye. 2000. Thiamin and riboflavin retention in ground beef patties pasteurized by electron beam. KAES Rpt. of Progress 850. Kansas State University, Manhattan.

Schoenbeck, M.K., D.H. Kropf, M.C. Hunt, S.L. Stroda, and S. Hawthorne. 2000. Effects of pH, myoglobin form, and endpoint temperature on cooked ground beef color. KAES Rpt of Progress 850. Kansas State University, Manhattan.

#### Bulletins, Seminars, Short Courses, Other Presentations

Kropf, D., H.J. Tuma, M. Sandberg, J. Santamaria, D. Schafer, M. Hunt and R. Smith. November, 1970. Effects of film permeability, freezing system, packaging time and display case temperature on frozen beef steaks. Study II. Effect of display light intensity on frozen beef steaks. Report to: E.I. DuPont De Nemours & Co.

Allen, D.M., M.C. Hunt, C.L. Kastner and D.H. Kropf. 1976. Kansas State University ResearchUp-Date. Improving systems of marketing red meat. Proc. Midwest Meat Processor's Seminar, Kansas State University. p. 3.

Allen, D.M., M.C. Hunt, C.L. Kastner, D.H. Kropf, V. Chen, A. Harrison, O. Corte, C. Kuntapanit, M.E. Smith and J. Thomas. 1976. Method of improving quality of grass-fed beef. Kansas State univ. Cattlemen's Day Report, No. 262. p. 79.

Allen, D.M., M.C. Hunt, C.L. Kastner, D.H. Kropf, G.H. Gutowski, A.R. Harrison and M.E. Smith. 1977. Characteristics of beef finished on selected feeding regimes. Kansas State Univ. Cattlemen's Day Rept. p. 105.

Hunt, M.C. 1978. Effect of feeding regime and time on feed on beef quality and yield. Proc. Midwest Meat Processors Seminar. p. E-1.

Allen, D.M., M.C. Hunt, C.L. Kastner, D.H. Kropf, A.R. Harrison, B.E. Brent and J. Riley. 1978. Effects on carcass traits of beef ration, energy level, and length of feeding. Kansas State Univ. Cattlemen's Day Report 320. p. 86.

Allen, D.M., M.C. Hunt, C.L. Kastner, D.H. Kropf, V. Chen, O. Corte, G.H. Gutowski, A.R. Harrison, C. Kuntapanit, J.D. Thomas and M.E. (Smith) McCurry. 1978. Carcass characteristics, palatability, and shelf life of beef finished on selected feeding regimens. Kansas State Univ. Cattlemen's Day Report 320. p. 79.

Hunt, M.C. 1979. Mechanical Blade Tenderization. Proc. MidWest Meat Processors Seminar. p. H-1.

Burson, D.E., M.C. Hunt, L.H. Hayward, C.L. Kastner, D.H. Kropf and D.M. Allen. 1979. Nutritional effects on beef palatability. Kansas State Univ. Cattlemen's Day Report 350. p. 65.

Burson, D.E., L.H. Hayward, M.C. Hunt, C.L. Kastner and D.H. Kropf. 1979. Mechanical tenderization of meat. Kansas State Univ. Cattlemen's Day Report 350. p. 68.

Fung, D.Y.C., C. Kastner, M. Hunt, M. Dikeman and D. Kropf. 1979. Mesophilic and psychrotrophic populations of hot-boned and conventionally beef. Presented at Institute of Food Technologists Annual Meeting.

Harrison, A.R., D.H. Kropf, D.M. Allen, M.C. Hunt and C.L. Kastner. 1979. Relationship of various spectrophotometric reflectance measurements to beef muscle visual color. Ann. Meeting IFT.

Erickson, D.B., J.H. McCoy, J.B. Riley, D.S. Chung, P.G. Nason, D.M. Allen, M.E. Dikeman, D.Y.C. Fung, M.C. Hunt, C.L. Kastner and D.H. Kropf. 1980. Hot processing: economic feasibility of hot processing beef carcasses. Bulletin 639. Kansas Agricultural Experiment Station, Manhattan.

Hunt, M.C., J.L.A. Kendall, M.E. Dikeman, C.L. Kastner and D.H. Kropf. 1980. Ground beef from electrically stimulated and pre-rigor processed carcasses. Kansas State Univ. Cattlemen's Day Report, No. 377. p. 12.

McCoy, J., P. Nason, D. Chung, C. Kastner, A. Lawrence, M. Dikeman, M. Hunt and D. Kropf. 1980. Hot processing--potential for application in the beef processing industry. Study I: Economic feasibility of hot processing beef carcasses. Kansas State Univ. Cattlemen's Day Report, No. 377. p. 3.

Nagele, K., M.E. Dikeman, M.C. Hunt, C.L. Kastner, D.H. Kropf and M. Lyon. 1980. Hot processing--potential for application in the beef processing industry. Study II. Electrically stimulated and hot-processed beef--color and eating qualities. Kansas State Univ. Cattlemen's Day Report, No. 377. p. 5.

Fung, D.Y.C., C-Y. Lee, C. Kastner, M. Dikeman, M. Hunt, D. Kropf and M. Lyon. 1980. Hot processing--potential for application in the beef processing industry. Study III: Hot processed beef--microbiological characteristics. Kansas State Univ. Cattlemen's Day Report, No. 377. p. 7.

Fung, D.Y.C., C.L. Kastner, M.C. Hunt, M.E. Dikeman and D.H. Kropf. 1980. Recent developments in microbiological studies on hot-boned beef. Proc. Internatl. Symp. on Recent Advances in Food Sci. and Technol., Jan. 9-11, Taipei, Rep. of China. Vol. II. p. 341.

Hunt, M.C. 1980. Renovation of KSU meat laboratory. Proc. Midwest Meat Processors Seminar.

Hunt, M.C. 1980. Energy use in the meat industry. KSU Energy Symposium.

Wu, J.J., C.L. Kastner, M.C. Hunt, D.H. Kropf and D.M. Allen. 1981. Nutritional effects of beef connective tissue characteristics and eating qualities. Kansas State Univ. Cattlemen's Day Report, No. 394. p. 19.

Hunt, M.C. 1981. Potential beef carcass grade changes. Presentation at Cattlemen's Day.

Hunt, M.C. 1981. Tumbling and massaging. Presentation at KSU Curing School.

Hunt, M.C. 1981. Packaging of cured meat. Presentation at KSU Curing School.

Bowles, J.E., C.L. Kastner, M.E. Dikeman, M.C. Hunt, J.L.A. Kendall and M. Lyon. 1981. Continuous versus intermittent electrical stimulation of beef carcasses and their effect on hot-boned muscle pH decline. Kansas State Univ. Cattlemen's Day Report No. 394, p. 25.

Greathouse, J.R., M.C. Hunt, D.E. Schafer and D.H. Kropf. 1981. Vacuum packaging of frozen bacon. Proc. Midwest Meat Processors Seminar. p. G-1.

Bowles, J.E., C.L. Kastner, M.E. Dikeman, M.C. Hunt, J.L.A. Kendall and M. Lyon. 1981. Continuous versus intermittent electrical stimulation of beef carcasses and their effect on hot-boned muscle pH decline. Kansas State Univ. Cattlemen's Day Report, No. 394. p. 25.

Greathouse, J.R., M.C. Hunt, M.E. Dikeman, L.R. Corah, C.L. Kastner and R. J. Pruitt. 1982. Effects of ralgro implants on growth, sexual development, carcass characteristics and eating quality of bulls implanted from birth to slaughter. Kansas State Univ. Cattlemen's Day Report No. 413. p. 60.

Hunt, M.C. 1982. Vacuum packaged ground beef and other fresh retail cuts. Proc. Midwest Meat Processors Seminar. p. F-1.

Burson, D.E., M.C. Hunt, D.E. Schafer, D. Beckwith and J.R. Garrison. 1982. Stunning method and time interval from stunning to bleeding effects on blood splashing in pork. Kansas State Univ. Swine Day Report No. 422, p. 122.

Greathouse, J.R., M.C. Hunt, D.E. Schafer, D.H. Kropf and J.L. A. Kendall. 1982. Packaging effects on storage of frozen bacon. Meat Plant Magazine. December p. 18.

Shivas, S.D., C.L. Kastner, M.E. Dikeman, M.C. Hunt and D.H. Kropf. 1983. Eating and cooking loss characteristics of electrically stimulated and hot boned bull inside round muscle chilled at different rates. Kansas State Univ. Cattlemen's Day Report No. 427, p. 69.

Choi, Y.I., C.L. Kastner, M.E. Dikeman, M.C. Hunt and D.H. Kropf. 1983. Effects of electrical stimulation and hot boning on the functional characteristics of presalted beef muscle used in sausage manufacturing. Kansas State Univ. Cattleman's Day Report No. 427, p. 74.

Shivas, S.D., D.H. Kropf, C.L. Kastner, M.C. Hunt, J.L.A. Kendall and A.D. Dayton. 1983. Ascorbic acid and ground beef display life. Kansas State Univ. Cattlemen's Day Report No. 427, p. 74.

Hunt, M.C. 1983. Factors affecting meat tenderness. Proc. Midwest Meat Processors Seminar. B-1.

Kropf, D.H., M.E. Dikeman, M.C. Hunt and H.R. Cross. 1983. Lighting effects on beef carcass grade factors. Kansas State Univ. Cattlemen's Day Report No. 427, p. 76.

Timmis, T., G. Highfill, M.E. Dikeman, M.C. Hunt and R.H. Hines. 1983. Effect of Compudose on elimination of boar odor. Kansas State Univ. Swine Day Report No. 442, p. 115.

Hunt, M.C. 1984. Making sausage meats work for you. Proc. Kansas-Nebraska Sausage School.

Axe, J.B., C.L. Kastner, M.E. Dikeman, M.E. Hunt, D.H. Kropf and D.G. Gray. 1984. Effects of low voltage electrical stimulation during bleeding and hot boning on beef loineye and top round muscles. Kansas State Univ. Cattlemen's Day Report No. 448, p. 1.

Unruh, J.A., C.L. Kastner, D.H. Kropf, M.E. Dikeman and M.C. Hunt. 1984. Effects of low voltage electrical stimulation during bleeding on characteristics of beef loineye and top round muscles. Kansas State Univ. Cattlemen's Day Report No. 448, p. 6.

Timmis, T., M.E. Dikeman, M.C. Hunt, R.H. Hines, G. Highfill and J.S. Stevenson. 1984. Effects of compudose implants on performance, carcass, meat quality traits and serum testosterone in young boars. Kansas State Univ. Swine Day Report No. 461, p. 92.

Kropf, D.H. and M.C. Hunt. 1985. Packaging and Meat Color. MSU Packaging Symposium.

Kluber, III, E.F., D.S. Pollmann, D.L. Davis, J.S. Stevenson, M.C. Hunt, J.E. Minton and J.L. Nelssen. 1985. Body growth and testicular characteristics of boars fed a synthetic progestogen, altrenogest. Kansas State Univ. Swine Day Report No. 486, p. 112.

Flores, H.A., C.L. Kastner, D.H. Kropf and M.C. Hunt. 1986. Methods of tenderization for value-added, hot-boned, restructured, pre-cooked roasts from cows. Kansas State Univ. Cattlemen's Day Report No. 494, p. 88.

Hunt, M.C. and D.E. Schafer. 1986. Diet, health, nutrition - some issues involving meat. Proc. Midwest Meat Processors Seminar. H-1.

Kropf, D.H., M.C. Hunt and Dorly Piske. 1987. Color formation and retention in fresh beef. Kansas State Univ. Cattlemen's Day Report No. 514, p. 44.

- Todd, S.L., J.R. Claus, F.E. Cunningham and M.C. Hunt. 1987. Pork nuggets formulated with dietary fiber. Kansas State Univ. Swine Day Report No. 528, p. 114.

Kropf, D.H., S. Hung and M.C. Hunt. 1987. Effect of display lighting on fresh pork longissimus packaged in oxygen-permeable and oxygen-barrier films. Kansas State Univ. Swine Day Report No. 528, p. 101.

Goll, S.J., C.L. Kastner, M.C. Hunt and D.H. Kropf. 1988. Effects of sugar, internal cooking temperature, and hot-boning on the characteristics of low-fat, restructured, value-added beef roasts. Kansas State Univ. Cattlemen's Day Report No. 539, p. 81.

Hunt, M.C. 1988. Cholesterol in meat. Kansas State Univ. Cattlemen's Day Report, No. 539.

Claus, J.R., M.C. Hunt and C.L. Kastner. 1988. Effects of substituting added water for fat on the textural, sensory and processing characteristics of bologna. Proc. Midwest Meat Processors Seminar, p. C-1.

Hunt, M.C., G. Whipple-Van Patter, D.H. Kropf, R.D. Klemm, R.D. Goodband, J.L. Nelssen, R.H. Hines and B.R. Schricker. 1989. Will porcine somatotropin (pST) lower pork quality? Kansas State Univ. Swine Day Rept. of Progress 581, p. 171.

Kenney, P.B., C.L. Kastner, D.H. Kropf, M.C. Hunt and C. Garcia. 1989. Refining beef raw materials for further processing. Kansas State University Cattleman's Day.

Wang, H., D.H. Kropf, M.C. Hunt and C.L. Kastner. 1989. Iridescence in cooked beef. Kansas State University Cattleman's Day.

Dikeman, M.E., G. Whipple and M.C. Hunt. 1989. Characteristics responsible for tenderness differences in *Bos taurus* and *Bos indicus* cattle. Kansas Agric. Exp. Conference.

Hunt, M.C., K.E. Warren and D. H. Kropf. 1990. Packaging of pork loins. Kansas State Univ. Swine Day.

Hunt, M.C. 1990. Precooked deli meats. Proc. Missouri Meat Processors Assoc.

Wang, H., D.H. Kropf, M.C. Hunt and C.L. Kastner. 1990. Effects of processing variables on iridescence in precooked beef. Kansas State Univ. Cattlemen's Day Rept. of Progress 592, p. 48.

Whipple, G., M. Koohmaraie, M.E. Dikeman, J.D. Crouse, M.C. Hunt and R.D. Klemm. 1990. Evaluation of attributes affecting tenderness differences between *Bos taurus* and *Bos indicus* cattle. Kansas State Univ. Cattlemen's Day Rept. of Progress 592, p. 38.

Hunt, M.C. 1990. Developing low-fat beef products. Cattlemen's Day Presentation.

Warren, K.E., M.C. Hunt, C.L. Marksberry, O. Sørheim and D.H. Kropf. 1990. Bone-in pork loins: Modified atmosphere packaging to extend shelf life. Kansas State Univ. Swine Day Rept. of Progress 610, p. 108.

Kropf, D.H., O. Sorheim, M.C. Hunt, M. Menninen and K.E. Warren. 1990. Effects of Modified atmosphere packaging and carcass chill rate on pork loins. Kansas State Univ. Swine Day Rept. of Progress 610, p.112.

Garcia Zepeda, C.M., C.L. Kastner, D.H. Kropf, M.C. Hunt, P.B. Kenney, J.R. Schwenke and D.S. Schleusener. 1990. Utilization of surimi-like products from pork with sex-odor in restructured, precooked pork roasts. Kansas State Univ. Swine Day Rept. of Progress 610, p. 115.

Cunningham, F., D. Fung, M. Hunt, C. Kastner, D. Kropf, B. Larson, D. Schafer, D. Simms, S. Smith, and M. Vanek

Nold, R.A., J.A. Unruh, C.W. Spaeth, and M.C. Hunt. 1991. The effects of implanting ram and wether lambs with zeranol at birth and weaning on pelt removal and pelt characteristics. Kansas State Univ. Sheep Day Rept. of Progress 624, p.23.

Nold, R.A., J.A. Unruh, C.W. Spaeth, and M.C. Hunt. 1991. The effects of implanting ram and wether lambs with zeranol at birth and weaning on palatability characteristics. Kansas State Univ. Sheep Day Rept. of Progress 624, p.26.

Hunt, M.C. 1991. Low-fat ground beef: Industry applications. Cattlemen's Day Presentation.

Hunt, M.C. 1991. Complex carbohydrates, starches and dietary fiber in low-fat ground beef. National Low-fat Ground Beef Symposium--Baton Rouge, LA. National Live Stock and Meat Board.

Hunt, M.C. 1991. Low-fat ground beef: Technology Perspectives. National Press Conference, Waldorf Astoria, New York, NY. Sponsored by Ketchum Public Relations and the National Live Stock and Meat Board.

Hunt, M.C. 1991. Methods for production of low-fat ground beef. National Grocers Association Annual Meeting. Kansas City, MO.

Hunt, M.C. 1991. Low-fat ground beef--Applications and practice. Meat Operations Conference. National-American Wholesale Grocers' Association. Kansas City, MO.

Hunt, M.C. 1991. Development and manufacture of low-fat ground beef. Minnesota Grocers Association Annual Meeting. Minneapolis, MN.

Hunt, M.C. 1991. Low-fat regional press conference for food writers. Sponsored by the Minnesota Beef Council. Minneapolis, MN.

Hunt, M.C. 1992. Applications of low-fat meat technology to ground products. Proc. Kansas Midwest Meat Proces

Hunt, M.C., E.S. Troutt, C.L. Kastner, D.H. Kropf and S. Stroda. 1991. Low-fat ground beef. Kansas Agric. Exp. Conference.

Payne, C.A., K.E. Warren and M.C. Hunt. 1992. Nutritional effects on fiber characteristics of four bovine muscles varying in growth impetus. Kansas Agric. Exp. Conference.

Warren, K.E., C.A. Payne and M.C. Hunt. 1992. Influence of dry matter intake on animal growth, carcass composition and longissimus muscle tenderness in crossbred steers. Kansas Agric. Exp. Conference.

Campbell, R.E. and M.C. Hunt. 1992. Recovery of high quality lean and connective tissue from beef shanks. Kansas Agric. Exp. Conference.

Hunt, Melvin. 1992. Developing meat products -- an activity for high school students. Kansas Ag. Educ. Mid-w

Hunt, M.C. and D.H. Kropf. 1992. Fresh and processed meat color chemistry and color assessment. W.R. Grace

Hunt, Melvin. 1993. Relationship between meat packaging and meat color. Kansas Ag. Educ. Mid- winter Confe

Hunt, Melvin. 1993. New developments in beef processing. Cattlemen's Day Presentation.

Hunt, Melvin. 1993. Advanced technologies for the meat industry. Food and Agribus. Industry of Kansas City.

Carmack, C.F., C.L. Kastner, M.C. Hunt, D.H. Kropf and J.R. Schwenke. 1993. Can "natural" flavorings enhance the flavor of low-fat ground beef? Kansas State Univ. Cattlemen's Day Rpt. of Progress.

Marksberry, C.L., D.H. Kropf, M.C. Hunt, M.A. Hague, and K.E. Warren. 1993. Ground beef patty cooked color guide. Kan. Ag. Exp. Stat.

McCauley, W.H., D.H. Kropf, and M.C. Hunt. 1996. Cured meat color guide. Kan. Ag. Exp. Stat.

Hunt, M.C. 1997. Food safety and cooked color of ground beef patties. USDA Workshop. Washington, D.C.

Hawthorne, S.A., R. Lein, M.C. Hunt, and D.H. Kropf. 1999. Ground pork cooked color guide. Kan. Ag. Exp Stat.

Hawthorne, S.A., R. Lein, M.C. Hunt, and D.H. Kropf. 1999. Pork chop cooked color guide. Kan. Ag. Exp Stat.

Hunt, M.C. 1999. Distance learning program for Food Science at KSU. Provost Series on Education at KSU.

Hunt, M.C. 1999. Distance learning methods. KSU College of Agriculture Focus Series.

### Educational Materials

#### Course Syllabi:

Distance Learning - Complete course, *PRINCIPLES OF MEAT SCIENCE* in "any-time or real-time" distance learning format via audiotapes, teleconferencing, on-line discussions involving collaborative learning, problem solving and critical thinking via the Internet.

In-Class - Laboratory Materials for *MEAT SCIENCE*, a series of 14 study guides for lab exercises  
- Laboratory Materials for *PROCESSED MEAT OPERATIONS*

#### Other Materials and Activities:

USDA Grant: - Expanding Undergraduate Education for Food Industry Personnel via Technology.  
1994-96 USDA Challenge Grant Program, \$79,479

#### Web-based Course - Principles of Meat Science, KSU Division of Continuing Education

Color Guides - Ground Beef Patty Cooked Color Guide  
- Cured Meat Color Guide  
- Cooked Pork Chop Color Guide  
- Ground Pork Patty Cooked Color Guide

Science Series - Lesson Plans for: Promoting Ag Science for Secondary Schools  
Developing New Meat Products  
Color Chemistry in Meat Products  
Meat Packaging Exercises for High School Students

Slides Series: - Unraveling the Mystery of Premature Browning in Cooked Ground Beef Patties  
- Doneness of Cooked Ground Beef  
- Dynamics of Conversion of Myoglobin Forms  
- Role of Pigment Layers in Influencing Surface Meat Color  
- Spray Chilling of Carcasses  
- Don't be Broken-Hearted because of High-fat in Ground Beef  
- Commercial Sausage, Ham and Bacon Production  
- Food Science at KSU  
- ASI Quadrathlon - why I should participate  
- Updated: Muscle-Bone Anatomy; Beef-Pork-Lamb Cut Identification

Video Tapes: - Beef Carcass Electrical Stimulation and Hot Boning  
(Edited with M. E. Dikeman)

Store Survey: - Out-of-class assignment for Analysis of Retail Meat Section of Grocery Stores

Diet Survey: - Out-of-class assignment for computerized class project of Nutritional Value of Muscle Foods in the student's diet

Current topic: Survey - Out-of-class assignment for critically analyzing printed literature on a variety of livestock and meat industry topics

Web Sites: - Out-of-class assignment for evaluation and collection of scientific facts about muscle biology and meat science

### Theses and Dissertations

Gutowski, G.H. 1977. Effect of vacuum aging, display and level of nutrition on beef quality. M.S. Thesis, Kansas State University.

Hayward, L.H. 1978. Blade tenderization effects on subjective and instron objective textural measurements of longissimus steaks from cattle fed various nutritional regimes. M.S. Thesis, Kansas State University.

Burson, D.E. 1979. Ration energy density and time on feed effects on beef longissimus palatability. M.S. Thesis, Kansas State University.

Hall, J.B. 1981. Collagen solubility of A-maturity bovine longissimus muscle as affected by nutritional regimen. M.S. Thesis, Kansas State University.

Greathouse, J.R. 1982. Ralgro implanted bulls: Performance, carcass characteristics, longissimus palatability and carcass electrical stimulation. M.S. Thesis, Kansas State University.

Sleper, P.S. 1982. Myoglobin properties of electrically stimulated bovine longissimus muscle. M.S. Thesis, Kansas State University.

Highfill, G.A. 1984. Effects of sex and compudose implantation on porcine muscle histochemistry. M.S. Thesis, Kansas State University.

Burson, D.E. 1985. Effects of muscle, heat and sex on the proportions of types I and III bovine intramuscular collagen. Ph.D. Dissertation. Kansas State University.

Claus, J.R. 1989. Characterization of low-fat processed meat containing dietary fiber. Ph.D. Dissertation, Kansas State University.

Troutt, S.E. 1990. A chemical, physical and sensory characterization of low-fat ground beef. M.S. Thesis, Kansas State University.

Warren, K.E. 1990. Modified atmosphere packaging with 100% carbon dioxide for bone-in pork loins. M.S. Thesis, Kansas State University.

Hague, M.A. 1992. Internal and expressible juice color of cooked ground beef patties. M.S. Thesis, Kansas State University.

Londono Villegas, J.F. 1993. Effects of realimentation and trenbolone acetate implantation of cull cows on tenderness and cooked color. M.S. Thesis, Kansas State University.

Payne, A.C. 1993. Starch functionality and modification for batter sausages. PhD. Dissertation, Kansas State University.

Warren, K.E. 1994. Factors affecting premature browning of heated myoglobin. PhD. Dissertation, Kansas State University.

Conner, J.G. 1995. Fat trimming and vitamin E effects on subprimal and retail cut yields and shelf life. M.S. Thesis, Kansas State University.

Schoenbeck, J.J. 1997. Effects of carcass infusion on color and display life of several bovine muscles. M.S. Thesis, Kansas State University.

Clark, T.J. 1998. Rebloom and display color stability of beef and pork packaged in an ultra-low oxygen modified atmosphere active packaging system. M.S. Thesis, Kansas State University.

Campbell, R.E. 2000. Effects of internal structure, patty shrinkage, and desinewing on palatability attributes of ground beef. PhD dissertation.

Sammel, L.M. 2000. Chemical characterization, color stability, and comparison of assays for metmyoglobin reducing ability in beef inside and outside semimembranosus. MS thesis.

Lien, R. 2001. Effects of endpoint temperature, pork quality, and cooking factors on internal cooked color of pork chops and patties. MS thesis.

Wendelburg, J. 2001. Physical, chemical and microbial qualities of blade tenderized prime rib. MS Thesis.

Ballard, C. 2002. Carbon monoxide in modified atmosphere packaging. MS Thesis.

ERIC F. GREENBERG  
ATTORNEY AT LAW

ERIC F. GREENBERG  
Of Counsel  
Ungaretti & Harris

**Contains Confidential Business Information**

August 29, 2001

Division of GRAS Notice Review  
Office of Food Additive Safety  
Center for Food Safety and Applied Nutrition  
Food and Drug Administration  
200 C St, SW  
Washington, DC 20204

**Re: NOTIFICATION OF CLAIM FOR GENERAL  
RECOGNITION OF SAFETY OF CARBON MONOXIDE  
IN A MODIFIED ATMOSPHERE SYSTEM FOR  
PACKAGING FRESH MEAT**

To the FDA:

This letter and its attachments contains the notification, pursuant to the Federal Food, Drug and Cosmetic Act and FDA's regulations, by Pactiv Corporation, 1900 West Field Court, Lake Forest, Illinois 60045, c/o attorney Eric F. Greenberg, 3500 Three First National Plaza, Chicago, Illinois 60602<sup>1</sup>, for the General Recognition of Safety of carbon monoxide ("CO") at a level of 0.4% in a modified atmosphere system for packaging fresh meat.

---

<sup>1</sup> Attachment 1 contains Pactiv's authorization of undersigned counsel, as well as a Summary regarding Pactiv Corporation.

As set forth more fully below and in the attachments to this document, Pactiv believes its intended use of CO is GRAS based on scientific procedures within the meaning of 21 U.S.C. Sec. 201(s) and FDA's implementing regulations in 21 CFR Sec. 170.30, and including FDA's proposed rule published on April 17, 1997 (62 FR 18937). FDA regulations provide that the scientific evidence available and reviewed for a GRAS determination is of the same quantity and quality as that required for a food additive approval, and that the scientific evidence of safety be generally known and accepted by qualified experts in the appropriate scientific and technical fields. 21 CFR Sec. 170.30(a).

**I. Claim of Exemption**

**a. Name and address of the notifier.**

Pactiv Corporation  
1900 West Field Court  
Lake Forest, Illinois 60045  
c/o Eric F. Greenberg  
Attorney at Law  
3500 Three First National Plaza  
Chicago, IL 60602

**b. Common or usual name of the notified substance.**

Carbon monoxide ("CO")

c. Conditions of use (foods, levels, purposes).

When used as described in this Notice, CO meeting appropriate purity specifications is a processing aid in packaging of fresh cuts of muscle meat and ground meat, as a component of a gas mixture utilized in a specific modified atmosphere packaging system. 21 CFR Sec. 170.3(o)(24). A technology utilizing 0.4% CO within a modified atmosphere packaging system will maintain wholesomeness, permit greater flexibility in distribution, and reduce shrinkage, all within a system that results in traditional product display to consumers. All elements of the system, excluding the CO, are already in use in the United States as part of a modified atmosphere meat packaging system called ActiveTech™. Notifier refers to the new system incorporating CO as "AT2001".

### Summary

ActiveTech™ is a system that is designed to permit more extended storage of meats, but, as explained below, has no effects on retail display time or characteristics as compared with other modified atmosphere technologies currently in use. It employs materials that are either approved additives used consistently with their approvals, or GRAS substances. AT2001 adapts that system for additional storage scenarios. AT2001 serves to reduce the time needed for enzymatic reduction after modified

atmosphere packaging, and allows consistent display color of whole muscle meats. AT2001's advantages are in the resulting flexibility and consistency during storage and distribution.

The GRAS use of CO described in this Notice involves use as a component of the flush gas mixture used in replacement of ambient air in the packaging for distribution of refrigerated fresh red meat. The meats are in all instances fresh, and are intended to be cooked prior to consumption.

#### "Traditional" ActiveTech™

The ActiveTech™ modified atmosphere system, in commercial use in the United States since 1998, is a modified atmosphere system for packaging fresh cuts of muscle meat, or portions of ground meat. AT2001 is a refinement of ActiveTech™, and differs from it only in the addition of 0.4% CO to the modified atmosphere.

In the "traditional" ActiveTech™ system, the meats are placed in polystyrene trays and covered with oxygen-permeable, flexible polyvinyl chloride ("PVC") overwraps. The wrapped trays of meat are then placed within an outer barrier bag from which ambient air is removed and replaced with a blend of 30% carbon dioxide (CO<sub>2</sub>) and 70% nitrogen (N<sub>2</sub>). An activated oxygen-absorbing sachet is also added within the outer bag.

This modified atmosphere maintains the packaged meat in an oxygen-free deoxymyoglobin state, with its distinctive purplish appearance that is generally considered undesirable by consumers. The traditional ActiveTech™ system relies on the rapid reduction of the oxygen content of the outer bag. Once the oxygen is removed, a "seasoning" phase begins during which enzymatic effects take place so that the meat will be able to "re-bloom" when once again in the presence of oxygen. As the residual oxygen in the package is consumed by the activated oxygen scavenger, red meat oxymyoglobin is first subject to rapid conversion to metmyoglobin (brown) at very low partial pressures of oxygen, e.g. 0.5% oxygen. This low partial pressure region of oxygen is necessarily passed through prior to ultimately reaching 0% in the package and the conversion to deoxymyoglobin (purple). This seasoning phase can take up to 5 days.

Before display to consumers at retail, the outer bag, and thus the modified atmosphere, is removed, and the traditionally wrapped product (in polystyrene foam tray with PVC overwrap) is permitted to "re-bloom" to its familiar appearance through creation of oxymyoglobin on the meat's surface.

AT2001

In the AT2001 modified atmosphere system, as with traditional ActiveTech™, fresh cuts of muscle meat, or portions of ground meat, are placed in polystyrene trays and covered with oxygen permeable flexible PVC overwraps. The wrapped trays are placed within the outer barrier bag, the air is removed and replaced with a blend of 0.4% CO, 30% carbon dioxide (CO<sub>2</sub>) and the balance nitrogen (N<sub>2</sub>). As with the traditional AT system, an activated oxygen-absorbing sachet is added within the outer bag to create and maintain an oxygen-free environment for the packaged meat during storage.

As noted, meat packaged in traditional ActiveTech™ undergoes a myoglobin pigment conversion from oxymyoglobin (red) to metmyoglobin (brown) to deoxymyoglobin (purple) in the oxygen free environment. The metmyoglobin formed generally will convert to deoxymyoglobin in the oxygen free storage environment in about 5 days, a period of time referred to as the "seasoning period". However, the meat's ability to convert all of the metmyoglobin formed to deoxymyoglobin during the seasoning period and then fully rebloom to oxymyoglobin upon re-exposure to normal, oxygen-rich atmosphere at retail, is a function of a multitude of unpredictable, uncontrollable factors in the meat such as age, muscle

000008

location, and enzyme energy level. This is a key weakness of all current low oxygen packaging systems.

Meat packaged in the AT2001 atmosphere will instead convert from oxymyoglobin to carboxymyoglobin (red) in the package due to the inclusion of 0.4% CO in the modified atmosphere. This conversion occurs during the initial 24 hours as the free oxygen in the headspace is consumed. Thus, the CO effectively protects the myoglobin from converting to metmyoglobin as the oxygen in the package is removed. This feature is especially important for the most pigment sensitive meats such as those from the round. The meat will continue to maintain its red color while in storage until the package is opened for retail display, when the outer bag (and modified atmosphere) is removed. Since carboxymyoglobin and oxymyoglobin are essentially the same colors, no seasoning period is necessary. The meat can be opened for retail display the day following packaging.

Once in retail display, the meat's myoglobin will begin the rather slow, natural conversion to metmyoglobin (brown), akin to that seen with untreated meat, allowing for a conventional retail display life of 3 to 4 days, closer to consumers' expectations of color than results from use of high

oxygen packaging systems. Attachment 2 consists of photographs depicting the ActiveTech™ and AT2001 systems.

The AT2001 formulation will assure that the meat will have the familiar color during and following storage, eliminating the seasoning period, allowing for placement in retail display beginning at 1 day, and up to 30-40 days, after packing. For cuts of meat from the round, and other color sensitive cuts, the AT2001 will help them have a more uniform red color for retail display.

In AT2001 (as in traditional ActiveTech™ ), the trays and films utilized are made from familiar, FDA-approved polymers that are used in accordance with their existing approvals or GRAS status. The activated oxygen-absorbing sachet inserted into the outer bag to absorb oxygen does not contact food and is not expected to become a component of the food. Therefore, it is not a food additive under the definition in 21 USC Sec. 321(s). As an added assurance of safety, each of the sachet's components has some GRAS status or food-related approvals.

Thus, the AT2001 system adds a refinement to the existing ActiveTech™ system that will allow its utilization with whole and ground meat products that meet the processors' desire to get to market as soon as the day following processing.

d. Basis of GRAS determination: Scientific procedures

CO safety

Pactiv believes its proposed use of CO is GRAS based on scientific procedures within the meaning of 21 U.S.C. Sec. 201(s) and FDA's implementing regulations in 21 CFR Sec. 170.30 and including FDA's proposed rule published on April 17, 1997 (62 FR 18937).

CO is a colorless, odorless gas that is poisonous to humans if inhaled at much higher levels than are involved with the use that is the subject of this Notice. It is formed when carbon is not completely burned, for example, in the combustion of fuels.

It is well known that CO creates negative health effects at elevated levels because it out-competes oxygen for attachment to the hemoglobin molecule. The resulting carboxyhemoglobin levels in the blood are associated with severe health effects. In addition, the equilibrium rate for the exchange of carboxyhemoglobin for oxyhemoglobin is very slow, and the resulting level of carboxyhemoglobin is a function of the CO level in the respired air, the time of exposure and the level of activity of the individual. Typical atmospheric CO levels are <20 mg/m<sup>3</sup> as an 8 hour mean (higher in

urban and high traffic areas), and typical carboxyhemoglobin levels due to natural background CO range between 1.2 and 1.5%.

CO is recognized as a significant air pollutant at higher levels.

Automobile exhausts, industrial processes and boilers and incinerators all contribute to air quantities of CO. According to the U.S. EPA Office of Air and Radiation:

Carbon monoxide enters the blood stream and reduces oxygen delivery to the body's organs and tissues. The health threat from exposure to CO is most serious for those who suffer from cardiovascular disease. Healthy individuals are also affected, but only at higher levels of exposure. Exposure to elevated CO levels is associated with visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, and difficulty in performing complex tasks. EPA's health-based national air quality standard for CO is 9 parts per million (ppm) [10 mg/m<sup>3</sup>] measured as an annual second-maximum 8-hour average concentration.

"Summary regarding carbon monoxide" as part of discussions of 6 principal pollutants, U.S. EPA Office of Air and Radiation.

No health effects result when carboxyhemoglobin levels are under 4% to 5% in healthy adults. Carboxyhemoglobin levels of 2 to 3% may have negative effects on those with cardiovascular disease or other sensitivity. See, Environmental Health Criteria 13, Carbon Monoxide, World Health Organization, Geneva, Switzerland (1979), p. 15.

The US Occupational Safety and Health Administration's air contaminants regulation, 29 CFR Sec. 1910.1000, lists 50 ppm and approximately 55 mg/m<sup>3</sup> of CO as the 8-hour Time Weighted Average of exposure for the substance. 29 CFR Sec. 1910.1000.

By contrast, as explained below, the worst case estimated intake of CO attributable to AT2001 is 1.88 mg CO/meal.

The US FDA has not established an Acceptable Daily Intake for CO. Nevertheless, CO exposure, at levels much higher than those attributable to AT2001, for decades has been permitted within the existing FDA and USDA food additive regulatory provisions:

- Wood smoke ("smoke flavoring"), conventionally including CO as a component, is permitted by regulation as an ingredient in meat and poultry products pursuant to 9 CFR Secs. 318.7(c)(4)[meat], 381.147(c)(4)[poultry], 424.21(c).
- The specifications for Combustion product gas in 21 CFR Sec. 173.350 permit CO up to 4.5 percent by volume in such gases, which may be used in the processing and packaging of beverages and other foods except fresh meats, to remove and displace oxygen. Such gases are commonly used to package fruits and vegetables.

August 29, 2001

12

- In 2000, FDA responded favorably to GRAS Notice 000015 from Hawaii International Seafood, Inc. for the use of tasteless smoke, before freezing of tuna, as a preservative, specifically to preserve taste, aroma, texture and color. GRAS Notice (GRN) No. 000015, March 10, 2000. CO is a primary component of conventional smoke, which that Notice asserts is Generally Recognized As Safe based on decades of safe use in a variety of foods, which uses are recognized by FDA and incorporated into numerous food standards that permit smoking of cheeses. CO is also a primary component of tasteless smoke, along with nitrogen, oxygen, carbon dioxide and methane. The tasteless smoke is used to impart a "preservative effect." As noted in FDA's March 10, 2000 letter about the GRAS Notice, "In Hawaii International's view, tuna treated with tasteless smoke and tuna treated with conventional smoke contain comparable levels of carbon monoxide, carbon dioxide, hydrocarbons, and phenols." FDA's letter notes that it "has no questions at this time" regarding Hawaii International's conclusion that the use described is GRAS, though, in keeping with current regulatory practice, it had not made its own determination.

000014

CO is listed as a reproductive toxicant by the State of California pursuant to its Safe Drinking Water and Toxic Enforcement Act of 1986 ("Proposition 65"). California law contemplates that exposures to listed reproductive toxicants will be accompanied by a warning, unless the exposure is less than 1/1000<sup>th</sup> of an established no observable effect level. Cal. Health and Safety Code, Sec. 25249.6. No such level has been established for CO. Almost without question, though, any such future level (which will have a dubious connection to safety principles in any event, due to the design of Prop. 65), will be more than 1,000 times any possible exposure that could result from AT2001. The worst-case potential exposures from AT2001 are tiny fractions of the established occupational and environmental exposure levels (see below), which themselves are certain to be well below any level at which reproductive toxicity is ultimately deemed to result.

#### *Effects on Fresh Meat and Consumption*

Analysis of the AT2001 system makes plain the lack of any safety issue from consumption of treated meats. Additionally, similar technologies employing CO as part of a modified atmosphere gas mixture analyzed the technologies for effects on meat in terms of microbial load and organoleptic

properties including color, and for the safety of consumption of treated meats, specifically, any tendency of the consumed meat to expose consumers to levels of carboxymyoglobin. Further important evidence is obtained from examination of the actual experience since 1985 in Norway of packaging fresh red meats in 0.3 – 0.5 % CO for retail.

Safety: Effects on carboxymyoglobin levels

Consumption of meat treated with AT2001 is not expected to result in any measurable levels of carboxymyoglobin in the blood of those who consume treated meat.

An Estimated Daily Intake ("EDI") of CO attributable to the AT2001 use can be calculated as follows. First, we assume the following reasonable values for the exposure parameters:

- (1) An AT2001 bag contains 1.5 L modified atmosphere with a CO concentration of 0.4%, that is equivalent to approximately 0.006 L of CO in the bag ( = 6 mL CO).
- (2) At 28 g CO per mole and approximately 22.4 L per mole, the mass of CO per unit volume may be calculated:  $(28 \text{ g/mol})/(22.4 \text{ L/mol}) = 1.25 \text{ g/L} = 1.25 \text{ mg/mL}$ .

(3) The AT2001 bag contains 2 lbs (approximately 1.0 kg) of ground meat.

(4) Approximately 30% of the total amount of CO is absorbed into the meat (based on Watts, D.A.; Wolfe, S.K.; Brown, W.D., "Fate of [<sup>14</sup>C] Carbon Monoxide in Cooked or Store Ground Beef Samples", J. Agric. Food Chem., Vol. 26, No. 1 (1978), pp. 210-214). Therefore, the amount of CO taken up by the meat is  $[(0.3) * (6 \text{ mL/bag}) * (1.25 \text{ mg/mL})] / [1.0 \text{ kg meat/bag}] = 2.25 \text{ mg CO / kg meat.}$

(5) If we assume that a person consumes an 8.8 oz steak (250 g = 0.25 kg meat), or ground equivalent, at a single meal<sup>2</sup>, that 85% reduction in CO content occurs during cooking, and that 100% of the ingested CO is absorbed, then the maximum amount of CO exposure is  $(0.15) * (2.25 \text{ mg CO / kg meat}) * (0.25 \text{ kg meat/meal}) = 0.084 \text{ mg CO/meal.}$

Next, comparison may be made of the consumer EDI for CO to that amount inhaled during an 8-hour period at the EPA's National Ambient Air Quality Standard ("NAAQS") level. 40 CFR Sec. 50.8, National primary ambient air quality standards for carbon monoxide:

---

<sup>2</sup> Note that this is a conservative assumption. The EDI of beef for the 90<sup>th</sup> percentile intake per user is 139.2 g/d based on the most recent USDA national survey of food intake by individuals. Pactiv chose to use a larger value for beef consumption to simulate a typical to above-average consumption incident rather than an average over all meats.

The calculated, worst case consumer EDI for CO may be compared to that amount inhaled during an 8-hour period at the American Conference of Governmental Industrial Hygienists ("ACGIH") Threshold Limit Value ("TLV"). Documentation of the Threshold Limit Values and Biological Exposure Indices, p. 23, ACGIH, 1330 Kemper Meadow Drive, Cincinnati, Ohio.

- (1) The ACGIH TLV is 25 ppm CO is equivalent to approximately 28.9 mg CO per m<sup>3</sup> air.
- (2) The typical person breathes 15 m<sup>3</sup> air per day or approximately 5 m<sup>3</sup> air per 8-hours.
- (3) The exposure under these circumstances may be calculated as follows:

$$(28.9 \text{ mg/m}^3) * (5 \text{ m}^3 / 8\text{-hr}) = 145 \text{ mg CO / 8-hr.}$$

Thus, the ingestion of residual CO from the cooked meat is merely 1.3% of the exposure level at ACGIH TLV  $((1.88 \text{ mg}) / (145 \text{ mg}) = 0.013 = 1.3\%)$

Finally, the calculated worst case consumer EDI for CO may be compared to that amount inhaled during an 8-hour period at the OSHA PEL:

- (1) The OSHA PEL is 50 ppm CO is equivalent to approximately 58 mg CO per m<sup>3</sup> air.

(2) The typical person breathes 15 m<sup>3</sup> air per day or approximately 5 m<sup>3</sup> air per 8-hours.

(3) The exposure under these circumstances may be calculated as follows:

$$(58 \text{ mg/m}^3) * (5 \text{ m}^3/8\text{-hr}) = 290 \text{ mg CO / 8-hr.}$$

Thus, the ingestion of residual CO from the cooked meat is 0.65% of the exposure level at OSHA PEL. ((1.88 mg) / (290 mg) = 0.0065 = 0.65%).

Thus, the consumer EDI of CO from a eating meat packaged in the Active Tech 2001 bag is a small fraction of any of the currently allowed exposures by authoritative agencies. As these various limits were established to protect individual safety and health, it is plain that the worst case exposures that may result from AT2001 present no safety concerns whatsoever.

In the 1997 study, "Technological, hygienic and toxicological aspects of carbon monoxide used in modified-atmosphere packaging of meat" Trends in Food Science and Technology, September 1997 [Vol. 8], pp. 307-312, Sørheim, et al. concluded that meat packaged and displayed in an atmosphere combining 60 to 70% carbon dioxide, 30 to 40% nitrogen, and less than 0.5% CO "will result in only negligible levels of carboxyhemoglobin in the blood."

The authors note that there was sparse information in published literature on exposure to CO after consumption of meat treated with CO gas. They note that "the inhalation of air containing CO at a level of 55 mg per m<sup>3</sup> (the acceptable level in working environments in the USA) would provide a COHb level for a prolonged time period (hours) of at least 14 times that of the level reached temporarily on the consumption of 225 g of meat that has been packaged in CO at the saturation level for myoglobin." That estimate assumed saturation of meat myoglobin and hemoglobin was maximal and the transfer of CO from the gastrointestinal tract to the blood was 100%. Sørheim, et al. (1997), p. 310. The authors concluded, "Consequently, even for such a "worst case" scenario, the treatment of meat with CO gas appears to contribute very little to COHb levels, relative to levels that are considered safe in the working environment." Sørheim, et al. (1997), p. 310.

The authors report that "CO is lost from previously CO-treated meat during storage in the absence of CO, with a half life of ~3d." Sørheim, et al. (1997), p. 310. As these fresh meats are to be cooked before consumption, CO lost during cooking is also relevant. The authors report that "When the beef was cooked at 195° C, only 0.1 mg of CO remained

per kg of meat. The loss of CO amounted to ~85%." Sørheim, et al. (1997), p. 310.

The authors also compared CO exposure from the air and estimated exposure from CO-treated meat. Their comparative table is shown below.

Table 5. Theoretical Uptake of Carbon Monoxide (CO) in Blood

Exposure method	CO intake in 1 h	CO intake in 8 h
Lungs (15m <sup>3</sup> )	24 mg x 0.625 = 15.1 mg	9.2 mg x 5 = 46.0 mg
Meat (250 g CO treated)	0.025 mg	0.025 mg

Sørheim, et al. (1997), p. 311, Table 5.

Part of the authors' analysis was the premise that absorption of CO from the gastrointestinal tract into blood will in all probability be less effective than absorption from the lungs. The authors summarized the comparison as follows:

In order to prevent a maximum COHb level in the blood of 1.5% being exceeded, the CO concentration in air for a 1h period of moderate physical activity should not exceed 24 mg/m<sup>3</sup>, or 9.2 mg/m<sup>3</sup> in 8h (according to Table 4). In contrast, the consumption of meat that had been treated for 3d in an atmosphere containing 1% CO yielded ~0.1 mg of CO per kg of meat on storage and cooking.

Sørheim, et al. (1997), p. 310, citing Watts, D.A.; Wolfe, S.K.; Brown, W.D., "Fate of [<sup>14</sup>C]Carbon Monoxide in Cooked or Stored Ground Beef Samples", *J. Agric. Food Chem.*, Vol 26, No. 1 (1978), pp. 210-214.

The authors calculate that CO intake in 1h through the lungs taking in 15m<sup>3</sup> per day would result in 15.1 mg of CO, as compared with 0.025 mg of CO from intake of 250 g of CO treated meat. In 8 hours, the authors say the lungs will take in 46.0 mg, and the figure for meat would still be 0.025 mg. As the authors conclude,

Estimates detailed above indicate that, even assuming an improbable 100% absorption of CO from the gastrointestinal tract into the blood, the consumption of meat that has been treated with 1% CO will result in COHb levels that are negligible (approximately 3 orders of magnitude lower) compared with those resulting from exposure in the working environment to CO at an acceptable level. Consequently, it is highly improbable that CO exposure from meat packaged in an atmosphere containing up to 0.5% will represent a toxic threat to consumers through the formation of COHb.

Sørheim, et al. (1997), p. 310.

In another published report, the storage life and characteristics of meats packaged in a modified atmosphere including 0.4% CO were studied, but under circumstances distinguishable from AT2001. Sørheim O; Nissen, H; Nesbakken, T, "The Storage Life of Beef and Pork Packaged in an Atmosphere With Low Carbon Monoxide and High Carbon Dioxide", 52 Meat Science 157-164 (1999). In the study, the meats were packed in

modified atmosphere into retail-ready packages. This study examined off odor and microflora, as well as color, comparing the 0.4% CO/ 60% CO<sub>2</sub> /40% N<sub>2</sub> gas mixture with a gas mixture of 70% oxygen and 30% CO<sub>2</sub>.

Among the points made by these authors was that there is sometimes an objection raised against using CO in retail ready meats because "the colour stability can exceed the microbiological shelf life, with the risk of masking spoilage of the meat." Sørheim, et al. (1999), p. 163. (Citing Kropf, D.H. (1980), "Effects of retail display conditions on meat colour", *Proceedings of the Reciprocal Meat Conference*, 33, pp. 15-32.) The authors assert that in those circumstances, consumers would need to rely on off odors to evaluate microbiological conditions of meat. In addition, they caution, "When a MA with CO is applied commercially, it is important to have a proper control of hygienic condition of the meat raw materials and the chill chain temperatures." See Sørheim, et al. (1999), p. 163.

AT2001, by contrast, presents no such similar problems or needs for caution. AT2001 does not mask spoilage of the meat. AT2001 does not involve use of a modified atmosphere including CO in the retail package. Moreover, as noted below, Pactiv's own commissioned experimentation with AT2001 demonstrates that AT2001 retail packages will deteriorate in color beginning almost immediately after removal of the modified

atmosphere, and that microbial load will not reach unsafe levels while the color of AT2001 meat is still acceptable to the consumer.

Safety: The Norwegian experience

In Norway, CO has been used to package fresh meats, even at retail, since 1985, with commercially satisfactory and safe results.

The 2000 submission by the Norwegian Meat Cooperative and Norwegian Independent Meat Association to the EU Commission seeking Europe-wide approval of the use of CO, "Application For Assessment Of The Food Additive Carbon Monoxide (CO) Prior To Its Authorization", is Attachment 3. The evaluation undertakes a detailed analysis of the CO exposure expected through the described packaging use. See section entitled "IV. Report by Tore Aune: "Fresh Meat in Consumer Packaging-A Toxicological Evaluation of the Use of Up to 0.5% CO in a Gas Mixture".

As the Norwegian risk assessment analysis concludes, assuming a worst-case exposure of 0.1 mg/kg from consumption of 250 grams of heated CO-treated meat, CO intake can be expected to be 0.025 mg in 1 hour or even after 8 hours. Attachment 3, p. 000154. The cited study, Sørheim, et al. (1997), utilized meat that had been treated with 1% CO. According to the authors, to stay under maximum blood levels of carboxyhemoglobin of 1.5%, "the CO concentration in the air must be 24

milligrams per mg/m<sup>3</sup> for 1 hour at moderate physical activity at 9.2 mg/m<sup>3</sup> for 8 hours...." Attachment 3, p. 000154. Assuming an adult inhales 15 m<sup>3</sup> per 24 hours, this translates to 15.1 mg of CO taken in 1 hour, or 46.0 mg of CO taken in 8 hours. This is in dramatic contrast to the minuscule amount expected to be ingested through meat. The Norwegian authors conclude, "From a health perspective, the use of CO in concentrations below 0.5-1% for fresh meat thus represents no toxicological risk."

Attachment 3, p. 000155.

Safety: Exposure in environment

As a basis for comparison, the possible effect on ambient CO concentration associated with the release from a typical AT2001 barrier bag was estimated. A typical AT2001 barrier bag contains approximately 1.5 liters of modified atmosphere with a CO concentration of 0.4 percent, which is equivalent to approximately 0.006 liters of CO within the bag. On a mass basis, this volume of CO is equivalent to approximately 0.0075 g (7.5 mg) CO per bag.

Consider the possible use of the bag for storage of meat prior to retail display (e.g., at a supermarket). Any unassociated CO within the bag, it can be assumed, would be released to the meat processing area when the bag is opened, resulting in possible exposure by the employee(s) to the

released CO. The extent of such exposure is dependent on several factors, including the size of the meat processing area, air-mixing within the area and between adjacent areas, the number of bags opened, and the amount of free CO unassociated with the meat in the package. For these calculations, it has been conservatively assumed that none of the CO has become associated with the meat and is therefore all free to the ambient atmosphere upon opening of the package.

Assume, however, that the air volume within a meat processing area may reasonably range from 150 m<sup>3</sup> to 1,500 m<sup>3</sup>, which would represent several hundred to several thousand square feet of processing area. If each bag introduces 7.5 mg CO to the air within the processing area, the corresponding concentration of CO in air would be in the range of 0.005 mg/m<sup>3</sup> to 0.05 mg/m<sup>3</sup>, assuming conservatively that there is no air exchange between the processing area and other rooms or the outdoors. Thus, to exceed the occupational safety standard (i.e., threshold limit value, or TLV) of 25 ppm (29 mg/m<sup>3</sup>), 580 to 5,800 1.5 liter bags would need to be opened within an 8-hour period. As noted above, this assumes no mixing with other areas of the building or with outdoor air.

Thus, applying the reasonable assumption that the air volume within the processing area will be exchanged with external air once per hour,

opening of 580 to 5,800 bags per hour would be required to exceed the TLV, or 4,600 to 46,000 bags per work day. The number of bags opened within a given processing area will be a function of the size of the processing area, to a given extent, but is unlikely to even approach the number of bags required to result in air concentrations at the TLV. Actual concentrations in the work area of a secondary processing facility would likely be one to two orders of magnitude below the standard. Thus, opening of bags within a work area will not alter significantly the environmental exposure to CO.<sup>3</sup>

Regardless, the opening of the bags does not alter significantly the environmental exposure to CO. This action qualifies for a categorical exclusion from preparation of an environmental assessment pursuant to 21 CFR Sec. 25.32 (i), which provides an exemption for, in pertinent part, "Approval of a ...GRAS affirmation petition...." 21 CFR Sec. 25.32(i). The regulation makes no specific mention of the GRAS Notice procedure, but similar treatment is warranted for a GRAS Notice. (We also note that CO as used here also qualifies for exclusion under 21 CFR Sec. 25.32(r), as CO "occurs naturally in the environment" and the noticed use "does not alter significantly the concentration or distribution of the substance, its

---

<sup>3</sup> As an aside, there is no reason to expect any difficulty achieving compliance with the OSHA Threshold

metabolites, or degradation products in the environment." 21 CFR Sec. 25.32(r).)

*Corroborative information about AT2001*

The specific AT2001 system has been thoroughly tested to confirm that it results in the expected limited exposures to CO, and has no adverse effects on the treated meats. A study of meats treated with AT2001 commissioned by Pactiv examined its effects on initial product color, stability of color during display, and the central safety consideration of the relationships between color deterioration and microbial populations.

The study, conducted by faculty of the Department of Animal Sciences & Industry of Kansas State University, Manhattan, Kansas, examined steaks from three cuts of beef (strip loin, tenderloin, and inside round steaks), as well as ground beef. The study report is Attachment 4. The meats were packaged in AT2001 atmosphere, then stored at 35° F or 43° F for up to 35 days. Cuts were then placed under simulated retail conditions by being removed from the AT outer package and displayed at 34° F until their color approached consumer unacceptability. Comparisons

---

Limit Value at plants using the AT2000 technology to fill bags. Experimental use of an exhaust hood over the machinery has resulted in no measurable increase in CO ppm levels near the line.

000029

were made to similar products that had been exposed to oxygen but not CO.

Among the study's conclusions were:

(1) *Color: AT2001 system resulted in products that were equally red to products packaged with traditional oxygen permeable overwrap.* When the AT2001 outer bag was removed, the product's conversion to oxymyoglobin occurred red in 60-90 minutes and then had a typical bright red color. Visual appearance was improved, especially in the tenderloin and inner part of the inside round steaks, throughout display.

Color deterioration compared well to baseline products exposed to oxygen.

For tenderloin and inside round steaks, and to a lesser degree for ground beef, display time was increased only slightly in the AT2001 samples.

(2) *Bacterial growth: Bacterial growth was neither encouraged nor suppressed by the addition of CO to the ActiveTech™ gas blend (nitrogen and carbon dioxide), although microbial growth curves changed in slope and exponential growth according to the environment in the packages.* Aerobic bacteria and facultative anaerobes followed typical patterns of growth according to environmental conditions.

(3) *Spoilage indicators: CO neither masked spoilage, nor extended color life beyond the point of wholesomeness (i.e., the point of microbial soundness).*

A summary of the study follows.

A random selection of all steaks and ground beef packaged using oxygen-permeable polyvinyl chloride ("PVC") film were placed in display to serve as a baseline for color and microbiological comparisons. Products were expected to have the lowest microbiological load and ideal color stability using traditional packaging and display conditions for products exposed only to atmospheric oxygen. The inherent muscle chemistry responsible for good color life also was optimal. If the product exposed to CO were to have extended meat color life, then it will be compared to the baseline "control" with the "best" possible color.

To measure color changes, visual scores were considered the "standard" with instrumental color being discussed relative to its agreement or disagreement with the visual panel, ie, did the objective measurements confirm what the color panel saw? Visual scores of  $\geq 3.5$  were considered borderline acceptable. When samples reached this discoloration, they were removed from display. Normally,  $a^*$  values (higher values indicate more redness) are highly correlated to visual appraisal.

Inside round steaks typically are two-toned in color. The inner portion (ISM) is much less color stable than the outer portion (OSM). These portions were scored separately since one portion may have acceptable color while the other has unacceptable color that would be discriminated against by consumers resulting in the whole cut being judged unacceptable in color. The effects of CO on this bi-colored muscle were needed to confirm that color was not excessively extended in either portion.

Average fat and moisture contents of the ground beef were 19.5 and 61.6%, respectively. The pH of both intact muscles and the ground beef ranged from 5.3 to 5.7. The initial aerobic plate counts and lactic bacteria counts for all products were relatively low and indicative of good microbial quality of the raw materials and good sanitation. Furthermore, coliforms and *E. coli* were below the detection limit throughout the study.

The color of ground beef and steaks entering display (after MAP storage at 2 temperatures) was an attractive, typical red color. Although there were several significant differences in visual scores and a\* values (Attachment 9, Table 2 and Figures 1-10 at day 0) for product CO vs. baseline cuts, the variation in color was usually within  $\pm 0.5$  of a color score.

Color results: In general, the initial color of product exposed to CO was very similar to the color of steaks from the baseline display (never exposed to CO). When differences occurred, they were more related to either storage temperature or postmortem age of the product.

Panelists did not consider the color of product exposed to CO atypical. Cuts exposed to CO generally appeared more uniformly bright-red and would be expected to have high consumer appeal. These results were expected, as CO is known to preferentially form a ligand with the colored pigment (myoglobin) in meat resulting in a more intense red pigment known as carboxymyoglobin.

In the AT2001 system, Pactiv uses a low level of 0.4% CO, and obtains a red color very similar to the normal red oxymyoglobin pigment of fresh meats exposed to oxygen.

Color stability results: A critical next question was whether the carboxymyoglobin formed on the surface was more stable than the oxymyoglobin formed in baseline product. Further, did the carboxymyoglobin deteriorate in a predictable way that consumers could continue to use visual color to judge freshness or potential spoilage?

Product exposed to CO during MAP storage had color deterioration during display. (See visual panel scores (Attachment 4, Figures 1-5) and

instrumental color ( $a^*$  values, Attachment 4, Figures 6-10).) As expected, visual scores increased (color deteriorated) and  $a^*$  values decreased (loss of redness) as days in display increased. In several instances, color appeared to improve late in display – as indicated by a decrease in visual scores (see ground beef, strips loins and tenderloins at 43°F). These decreases were not a return of redness, but resulted from removal of discolored packages the preceding period, leaving product with less overall discoloration remaining in the case.

In general, the color deterioration profiles followed an expected pattern. Namely, the freshest product (baseline packages) had the most stable, red color and the most days in display needed to reach borderline discoloration of all treatments. (Attachment 4, Table 3 scores to 3.5) Exceptions occurred for the inside portion of the inside round and tenderloin products, where the product exposed to CO had slightly more stable color than the baseline product (Attachment 4, Table 3). These two muscle areas are well known by retailers as having short color life. Thus, CO appeared to improve color life when the inherent muscle chemistry desired for color was limited.

For product from MAP, the longer the storage time, the faster the deterioration, especially at the higher storage temperature (Attachment 4,

Tables 2 and 3). For packages stored at 43°F, which was a mildly abusive temperature, color deterioration would be expected to accelerate. This phenomenon also is illustrated in Attachment 4, Figures 1-10.

There was no evidence the color shelf life was unexpectedly lengthened by exposure of meat to CO in MAP. Changes in  $a^*$  values (and other instrumental measures of color not shown) followed the same pattern of color deterioration observed by the visual panelists.

Color and microbial data: Initial, pre-display microbiological data suggested that the raw materials were fresh and processed using good hygienic practices. For intact cuts, lactic acid bacteria, generic *E. coli*, and total coliform counts were below the detection limit of 1.76 colony forming units (CFU)/in<sup>2</sup>. Initial, pre-display aerobic plate counts ("APC") for intact muscles ranged from 1 to  $1.63 \log_{10}$  CFU/in<sup>2</sup>. Post-display counts were higher ( $P<0.05$ ) than pre-display APC which was an increase in bacterial proliferation and typical deterioration. However, all product had sufficient microbes to be susceptible to spoilage.

Baseline products were pulled from display when the visual panel scores reached  $\geq 3.5$ . However, the APC did not exceed  $5 \log_{10}$  CFU/unit as shown in Attachment 4, Figures 15-18. Furthermore, off-odor scores for

product at end of display (Attachment 4, Table 3) ranged from no to slight off odor.

Thus, color life in this base population did not exceed microbial soundness, which is generally accepted as < 100 million CFU/g hamburger ( $<1 \times 10^8$ ). (Principles of Meat Science, 3d Ed., Hedrick, H.B.; Aberle, ED, Forrest, JD; Judge, MD; Merkel, RA, Eds, Kendall/Hunt Publishing Co., Dubuque, Iowa.

Similar trends in microbial growth occurred in post-displayed samples stored in MAP compared to baseline products. Microbial patterns for product deterioration are shown in Attachment 4, Table 4 and Figures 11-18. Products stored under MAP at a slightly abusive temperature showed, as expected, a more rapid increase ( $P<0.05$ ) in microbial counts compared to samples stored at 35°F. For post-MAP (pre-display) and post-display samples, APC were higher at 45°F than 35°F (Table 4), and during the later days of storage at the higher temperature, differences were more obvious. Significant changes ( $P<0.05$ ) occurred in all cuts and ground beef with the exception of semimembranosus muscle. Counts for the SM muscle were lower than expected and no significant changes occurring until day 35 of MAP storage. This suggests that quality products that have been handled

in a sanitary fashion can be stored in the AT2001 system up to 35 days without comprising microbial quality.

The APCs for intact strip loin and tenderloin steaks stored at 35°F were lower ( $P<0.05$ ) on all days of display on days 21 and 35 post-MAP than steaks stored at 43°F (Attachment 4, Figures 12 and 14). Although products did not show a difference in APCs 7 days post-MAP, those products stored at the higher temperature (43°F) were more inferior 21 and 35 days post-MAP.

One goal of this research was to see if the color of CO-treated meat might mask spoilage. Visual color scoring was considered as the "standard" for determining the time to remove products from display. Because the visual panel scores were the deciding factor for length of shelf life, the interdependence between visual color and APC, LAB, and odor were considered quite important.

Attachment 4, Figures 19-21 show aerobic and lactic bacterial growth and odor scores at the end of display plotted against their corresponding visual color scores. All data observations were summed over storage temperature, storage time, and product type and plotted in one graph. If color masked spoilage, then there would be multiple points in the upper left

August 29, 2001

36

quadrant of the plot, the area represented by unacceptable microbial counts and off odors but with acceptable color (i.e., scores <3.5).

This did not occur with any frequency in any of the three plots. Thus, it does not appear that exposure of meat to CO during extended (up to 35 days at either 35° or 43°F) caused meat color to hide spoilage.

**e. Statement of availability of information**

Notifier has relied on published studies and generally accepted scientific data and information as the basis of its conclusions, and those of its panel of experts, about the safety and the general recognition of a modified atmosphere system for meat incorporating 0.4% CO in the gas mixture.

**II. Identity of notified substance**

1. Chemical name: Carbon monoxide
2. Chemical Abstracts Service: 630-08-0
3. Composition Specifications for food-grade material: The CO

employed in this system is to be of suitable purity for food contact. Specifically, this will mean a 99.99% minimum purity, as supplied by Pactiv's commercial gas supplier, Haun Welding Supply, Inc., 6481 Ridings

000038

Road, Syracuse, NY 13206. Attachment 5. The supplier's CO meets the following specifications, and will be referred to as "commercial grade":

Component	Specification
Carbon Monoxide	99.99% min.
Oxygen	≤ 0.5 PPM
Nitrogen	≤ 10 PPM
Carbon Dioxide	≤ 20 PPM
Methane	≤ 5 PPM
Ethane	≤ 1 PPM
Propane	≤ 1 PPM
Dimethyl Ether	≤ 1 PPM
Hydrogen	≤ 1 PPM
Moisture	≤ 1 PPM

4. Properties:

Relative molecule mass	28.01
Critical point	-140.2 °C at 34.5 atm (3.5 MPa)
Melting point	-205.1 °C
Boiling point	-191.5 °C
Density, at 0 °C, 1 atm	1.250 g/litre
at 25 °C, 1 atm	1.145 g/litre
Specific gravity relative to air	0.967
Solubility in water at 0 °C, 1 atm	3.54 ml/100 ml
at 25 °C, 1 atm	2.14 ml/100 ml
at 37 °C, 1 atm	1.83 ml/100 ml <sup>a</sup>
Conversion factors:	
at 0 °C, 1 atm	1 mg/m <sup>3</sup> = 0.800 ppm <sup>b</sup> 1 ppm = 1.250 mg/m <sup>3</sup>
at 25 °C, 1 atm	1 mg/m <sup>3</sup> = 0.873 ppm 1 ppm = 1.145 mg/m <sup>3</sup>

<sup>a</sup> Value obtained by graphic or calculated interpolation (Altman et al., 1971).

<sup>b</sup> Parts per million by volume

5. Analyses: ASTM D1946, "Analysis of Reformed Gas by Gas Chromatography (GC) with Thermal Conductivity Detection (TCD)", may be utilized to measure the quantity of CO present in gas mixtures. A copy of the method is Attachment 6.

### III. Self-limiting levels of use

Studies of modified atmospheres for packaging meat that contained both higher and lower levels of CO have established that the 0.4% used in the AT2001 system both has advantageous characteristics and avoids disadvantages seen with lower or higher levels. A CO level of 0.4% is sufficient to produce stable, cherry red color, (Sørheim, et al. (1997), and use of CO through retail display time may result in masked spoilage.

### IV. Basis of GRAS determination.

Pactiv believes its use of CO is GRAS based on scientific procedures, 21 CFR Sec. 170.30(b), and convened a panel of experts qualified by scientific training and experience to evaluate the safety of food, food additives and food ingredients. The experts have reviewed and evaluated the publicly available information summarized in this GRAS Notice. Their testimonial

letters are attached as Attachments 7 through 10. The above discussion and citations to generally available accepted scientific data, information, methods and principles relied upon, together with the anticipated consumption levels for both CO and meat treated with CO, provide ample basis to conclude that the use of CO at 0.4% in a modified atmosphere for packaging fresh meats is both safe and generally recognized as such by qualified experts.

The panel consisted of the following experts, whose GRAS opinions and curricula vitae are attached as attachments 7 through 10.

1. Daren Cornforth, Ph.D.  
Professor  
Department of Nutrition and Food Sciences  
Utah State University  
750 N. 1200 E.  
Logan, Utah 84322-8700

Dr. Cornforth is a professor in Nutrition and Food Sciences at Utah State University, Logan, Utah, and received his Ph.D. in food science and human nutrition from Michigan State University. He has performed extensive research and published multiple articles on the subject of meat color.

2. Vasilios Frankos, Ph.D.  
Principal  
Environ Corp.  
4350 N. Fairfax Dr.

Suite 300  
Arlington VA 22203

Dr. Frankos is a Principal at ENVIRON corporation, Arlington, Virginia, a scientific consulting firm, and has over 20 years of experience in the toxicological and pharmacological evaluation of data used to assess the risks posed by foods, food additives, and other substances. He holds a Ph. D. from the University of Maryland Pharmacy School in Pharmacology and Toxicology.

3. Melvin C. Hunt, Ph.D  
Professor  
Weber Hall  
Dept. of Animal Sciences and Industry  
Kansas State University  
Manhattan, KS 65506

Dr. Hunt is a professor of food science at the Department of Animal Sciences and Industry at Kansas State University, Manhattan, Kansas. He received his Ph.D. in food science at the University of Missouri. Among his many research projects and publications are multiple studies relating to meat color and the effects of various environments on meat color.

4. Oddvin Sørheim, Ph.D.  
Senior Research Technologist  
MATFORSK – Norwegian Food  
Research Institute  
Osloveien 1

N-1430 Ås  
Norway

Dr. Sørheim is a Senior Research Technologist at the Norwegian Food Research Institute, Osloveien, Norway. He received his Ph.D. in food science from the Agricultural University of Norway, and has performed extensive research and industry consultation, and published numerous articles on meat, including extensive experience with the use of CO in modified atmosphere packaging of meat.

Pactiv is not aware of any reports of investigations that are inconsistent with the GRAS determination relating to the use described.

### Conclusion

Based on all the above information, Pactiv Corporation has concluded that its use of 0.4% CO within the AT2001 modified atmosphere system for packaging fresh meat is Generally Recognized as Safe within the meaning of 21 U.S.C. Sec. 321(s).

Sincerely,

  
Eric F. Greenberg



Kansas State University

Animal Sciences and Industry  
K-State Research and Extension  
232 Weber Hall  
Manhattan, KS 66506-0201  
785-532-6533  
Fax: 785-532-7059

August 8, 2001

Eric F. Greenberg  
Of Counsel  
Ungaretti & Harris  
3500 Three First National Plaza  
Chicago, IL 60602-4283

Dear Mr. Greenberg:

The purpose of this letter is to confirm that I believe the use of a small quantity of carbon monoxide in the modified packaging system known as ActiveTech (by PACTIV) is safe and should qualify as GRAS. I have been a research meat scientist for nearly 30 years and have focused most of that time on factors affecting meat color and shelf life, including packaging systems. Thus, I am familiar with most of the world literature on such systems.

Based on my review of the details of the ActiveTech 2001 modified atmosphere system employing 0.4% carbon monoxide gas in a mixture with 60 percent carbon dioxide and the remainder nitrogen, as well as the published literature and common knowledge in the field, I am confident that the use of modified atmosphere including small quantities of carbon monoxide (0.4%) to package fresh meats as used in ActiveTech 2001 system is both safe and generally recognized as safe.

Sincerely,

A handwritten signature in black ink that reads "Melvin C. Hunt".

Melvin C. Hunt  
Professor

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No. : 09/915,150  
Applicant : Gary R. DelDuca *et al.*  
Filed : July 25, 2001  
Title : Modified Atmospheric Packages and Methods for Making the Same  
  
TC/A.U. : 1761  
Examiner : Robert A. Madsen  
  
Docket No. : 47097-01080

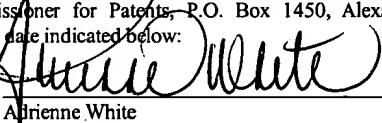
**SECOND DECLARATION OF GARY R. DELDUCA**  
**UNDER 37 C.F.R. § 1.132**

Mail Stop Amendments  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313

**CERTIFICATE OF MAILING**  
37 C.F.R. 1.8

I hereby certify that this correspondence is being deposited with the U.S. Postal Service as First Class Mail in an envelope addressed to: Mail Stop Amendments, Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313 on the date indicated below:

June 16, 2004  
Date

  
Adrienne White

Dear Commissioner:

I, Gary R. DelDuca, declare that:

1. I hold a degree of B.S. in Mechanical Engineering From Rochester Institute of Technology in Rochester, New York that was obtained in 1980.
2. From 1980-1995, I worked as a developmental and senior engineer for Mobil Chemical Company, Plastics Division. As a developmental engineer, I worked in process and product development in the area of foam products. As a senior engineer, some of my responsibilities included designing specialized machinery that included machinery directed to stacking trays for meat processes. Mobil Chemical Company, Plastics Division was purchased by Tenneco Inc. in 1995. From 1995 to the present, I have been a Technical Manager for

Tenneco Packaging Inc. in the area of modified atmosphere packaging (MAP) for meats. My responsibilities have included designing, developing, and implementing such modified atmosphere packaging for meat and processes using the same. In 1999, Tenneco Packaging Inc. was renamed Pactiv Corporation ("Pactiv").

3. I am familiar with claims 1-37, 87-90, and 161-171, that are directed to methods of manufacturing a modified atmosphere package. I am aware of the Office Action dated February 17, 2004, and the obviousness rejections in that Office Action. I understand that the analysis of the patentability of claims 1-37, 87-90 and 161-171 should take into account certain facts related to the commercial success, and the clinical or verification success of the MAP method that is covered by these claims. I wish to provide evidence showing that the Pactiv improved ActiveTech® meat packaging system and process have been commercially successful. Additionally, I wish to provide evidence that the Pactiv improved ActiveTech® meat packaging system and process have achieved substantial clinical effectiveness.

4. Pactiv and its predecessor Tenneco Packaging Inc.<sup>1</sup> have sold modified atmosphere packaging systems beginning in 1998 (the traditional ActiveTech® meat packaging system). The Pactiv traditional ActiveTech® meat packaging system includes meats being placed in polystyrene trays and covered with oxygen-permeable, polyvinyl chloride ("PVC") overwraps. The wrapped trays of meat are then placed in an outer barrier bag. Ambient air is removed and replaced with a blend of 30 vol.% carbon dioxide, and the balance being nitrogen.

5. Beginning in March of 2002, Pactiv began offering for sale an improved ActiveTech® meat packaging system. Pactiv's improved ActiveTech® meat packaging system

---

<sup>1</sup> These will be collectively referred to Pactiv Corporation in the remainder of the declaration.

includes meats being placed in polystyrene trays and covered with oxygen-permeable, PVC overwraps. The wrapped trays of meat are then placed in an outer barrier bag. Ambient air is removed and replaced with a blend of 0.4 vol.% carbon monoxide (CO), 30 vol.% carbon dioxide, and the balance being nitrogen.

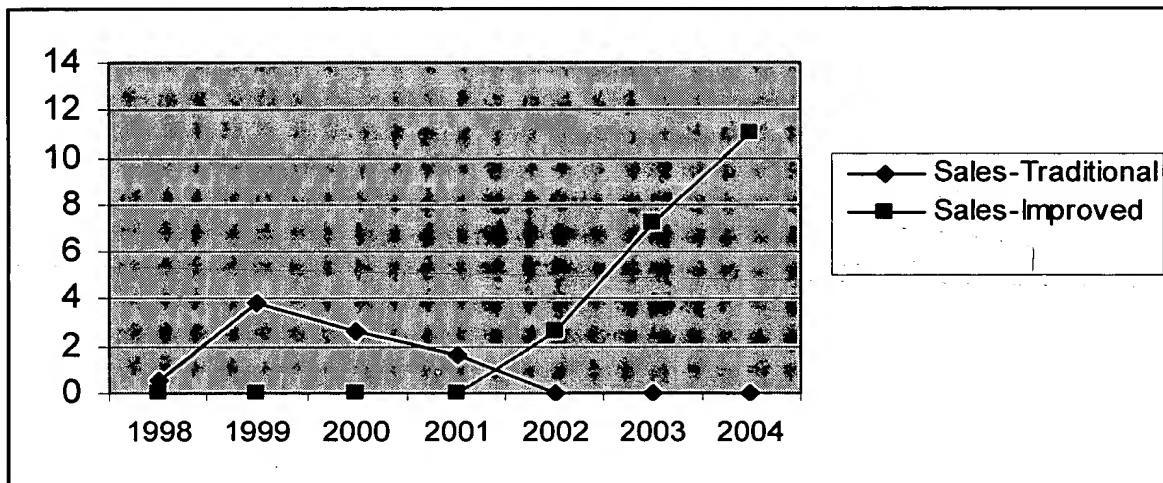
6. The modified atmosphere used in Pactiv's improved ActiveTech® meat packaging system differs from the modified atmosphere used in the Pactiv's traditional ActiveTech® meat packaging system. Specifically, Pactiv's improved ActiveTech® meat packaging system uses 0.4 vol.% CO, while Pactiv's traditional ActiveTech® meat packaging system does not use CO. Because of the addition of CO, the equipment used in Pactiv's improved ActiveTech® meat packaging system may vary slightly as compared to Pactiv's traditional ActiveTech® meat packaging system. Specifically, a mixer may be added to Pactiv's improved ActiveTech® meat packaging system to mix the CO, carbon dioxide, and nitrogen. Additionally, a CO gas recovery hood and safety features may also be included in Pactiv's improved ActiveTech® meat packaging system.

7. The purchasers of either Pactiv's improved ActiveTech® meat packaging system or Pactiv's traditional ActiveTech® meat packaging system receive a license for the process and the knowledge to run such a process. Pactiv allows its customers to use its oxygen-absorber dispensing-machine at no cost. The remaining machinery used to perform either Pactiv's improved ActiveTech® meat packaging system or Pactiv's traditional ActiveTech® meat packaging system is purchased by the customer. Typically, this remaining machinery is sold by

Pactiv to its customers. The customers also typically purchase the oxygen absorbers, trays, and film from Pactiv.

8. As shown below in the Graph and the Table, sales of Pactiv's traditional ActiveTech® meat packaging system were decreasing in 2000 and 2001. The sales of Pactiv's improved ActiveTech® meat packaging system, however, have increased at an exponential rate since its introduction in March of 2002. The sales of Pactiv's improved ActiveTech® meat packaging system have been commercially successful with sales numbers of over 7 million in 2003 and an estimated sales number of 11 million in 2004. The sales numbers below include the total of the purchased licenses, the purchased remaining machinery, and supplies (which include oxygen absorbers, activator fluid, and film).

GRAPH



TABLE

<b>U.S. Sales Year</b>	<b>Sales of Traditional ActiveTech® (in millions)</b>	<b>Sales of Improved ActiveTech® (in millions)<sup>2</sup></b>
1998	0.5	0
1999	3.8	0
2000	2.6	0
2001	1.6	0
2002	0	2.8
2003	0	7.2
2004	0	11 <sup>3</sup>

9. Since March of 2002, both Pactiv's improved ActiveTech® meat packaging system and Pactiv's traditional ActiveTech® meat packaging system have been available for sale. Since March 2002, no customer has purchased Pactiv's traditional ActiveTech® meat packaging system. In fact, every customer still practicing Pactiv's technology has converted its traditional ActiveTech® meat packaging system into Pactiv's improved ActiveTech® meat packaging system. Thus, to my knowledge no customer is still practicing Pactiv's traditional ActiveTech® meat packaging system. It can be concluded that these customers prefer the Pactiv's improved ActiveTech® meat packaging system over Pactiv's traditional ActiveTech® meat packaging system. The cost of Pactiv's improved ActiveTech® meat packaging system versus Pactiv's traditional ActiveTech® meat packaging system is fractionally more expensive. Thus, the commercial success of Pactiv's improved ActiveTech® meat packaging system cannot be attributed to a cost advantage.

---

<sup>2</sup> Pactiv's improved ActiveTech™ meat packaging system was not offered for sale until March 2002.

<sup>3</sup> This is an estimated figure based on sales through April of 2004.

10. The process of manufacturing using Pactiv's improved ActiveTech® meat packaging system is an example of a process that would be covered under independent claims 1, 22 and 161 of the present application.

11. After about 40 years of not allowing CO to be used with fresh meats in the United States, the Applicants came up with novel approaches of using CO in modified atmosphere packaging (MAP) systems that avoided the concerns of "fixing" the meat color, which can mask the spoilage or extend the life beyond the point of microbial soundness. The problem of fixing color using CO is known to those skilled in the art. One example of a reference that recognizes this problem is an article entitled "The storage life of beef and pork packaged in an atmosphere with low carbon monoxide and high carbon monoxide" to Sorheim, Nissen and Nesbakken. This article was discussed in the Office Action dated May 7, 2003.

12. The FDA stated that it had no questions regarding Pactiv's conclusion about Pactiv's improved ActiveTech® meat packaging system using 0.4% CO being GRAS because of the evidence presented by Pactiv in its GRAS notice. This FDA review allows Pactiv to use CO with fresh meat in its application. It is believed to be the first system to overcome the prohibition of CO with fresh meat in the U.S. in the last 40 years. Thus, an important advancement in the art of meat packaging systems has been accomplished by the present invention. The importance has been recognized by the customers of Pactiv's improved ActiveTech® meat packaging system and process.

13. I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true; and, further, that these statements were made with the knowledge that willful false statements and the like so made are

punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: June 16, 2004

  
\_\_\_\_\_  
Gary R. DelDuca



ADMINISTRATIVE CENTER • BENTON HARBOR, MICHIGAN

July 23, 1962

Mr. Alan T. Spiher, Jr.  
Food and Drug Administration  
Department of Health, Education and Welfare  
Washington 25, D. C.

Subject: Food Additive Petition No. 751

JA 3/9/62

Dear Mr. Spiher:

We are in receipt of your letter of May 10, 1962, advising us of the filing of Food Additive Petition No. 751 with an effective filing date of March 24, 1962.

In view of your comments in the above-mentioned letter, we now request that our petition as originally presented be amended so as to delete any reference to animal products wherein paragraph 121.1060, section (c) of Part 121, Sub-Part D of Title 21 would now read as follows:

(c) It is used or intended for use to displace or remove oxygen in the processing, storage, or packaging of citrus products, vegetable fats and vegetable oils, coffee, wine, fruit and fruit products and vegetable and vegetable products.

The following comments are submitted to further supplement the Remarks section of our first letter of March 6, 1962.

In food studies conducted at the Whirlpool Research Laboratories involving the use of combustion product gas as set forth in paragraph 121.1060 of Title 21, fruits and vegetables were stored under refrigeration at temperatures between

FAPB

1) A

1111 25 1000

32° and 45° F. and in their normal distribution containers, that is, baskets, crates and boxes. Products so stored had a shelf life of from three to five times that of air-stored food held at the same temperature. The results of one such study involving apples stored in air versus apples stored in conventional controlled atmosphere versus apples stored in combustion product gas are presented in the attached table. It will be noted that apples stored in combustion product gas had firmer flesh and a lower incidence of scald than did apples stored either in air or conventional controlled atmosphere even though the apples in combustion product gas were in storage for a longer period of time.

The combustion product gas under study at Whirlpool would most likely be used in the following general areas:

1. Fresh fruit and vegetable storage
2. Processors - storage, packaging and processing
3. Transportation

Because of these diverse applications, our petition requests approval for fruit and vegetable "products" as well as the natural, original raw fruits and vegetables.

To expand on the use of combustion product gas by food processors, the following examples are presented:

1. Storage of fruits and vegetables in order to have better quality control, improve yield and extend packaging season.
2. Packaging of processed foods in inert gases, i. e., nitrogen and/or carbon dioxide to prevent oxidative changes that may develop during storage.
3. Use of gas mixtures in certain processing steps as a "blanket" to keep out oxygen and prevent the associated undesirable changes.

Mr. Alan T. Spiher, Jr.

Page Three

We are hopeful that the requested amendment to the petition as well as the supplemental information presented above will clear up any questions concerning Food Additive Petition No. 751 and that favorable action will be shortly forthcoming.

Very truly yours,

WHIRLPOOL CORPORATION

*Barbara E. Mahaffay*  
Barbara E. Mahaffay  
Vice President